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Editorial

THE ARTIFICIAL SATELLITE

Few people interested in space-flight can have failed to note the wave of interest which broke across the front pages of the world's newspapers at the end of July. An official release at a news conference at the White House in Washington declared that Presidential approval had been given for the United States to take the first major step towards space-flight by launching earth satellites in the near future.

In July, 1957, begins a period known as the International Geophysical Year (I.G.Y.) in which the world's scientists are devoting a great part of their energy towards observations designed to make a big increase in our knowledge of the world, its atmosphere, and the way it is affected by external influences. The Washington statement makes it clear that a satellite vehicle will be one of the most valuable sources of information in the following words:—

"The atmosphere of the Earth acts as a huge shield against many of the types of radiation and objects that are found in outer space. It protects the Earth from things which are known to be or might be harmful to human life, such as excessive ultra-violet radiation, cosmic rays, and those solid particles known as meteorites.

"At the same time, however, it deprives man of the opportunity to observe many of the things that could contribute to a better understanding of the Universe.

"To acquire data that are presently unobtainable it is most important that scientists be able to place instruments outside the Earth's atmosphere in such a way that they can make continuing records of the various properties about which information is desired.

"In the past vertical rocket flights to extreme altitudes have provided some of the desired information, but such flights are limited to very short periods of time. Only by the use of a satellite can sustained observations in both space and time be achieved.

"Such observations will also indicate the conditions that would have to be met and the difficulties that would have to be overcome if the day comes when man goes beyond the atmosphere in his travels."

A few minutes earlier a similar announcement had been made at a meeting in Brussels by the Secretary of the I.G.Y. Committee, Dr. Marcel Nicolet, of Belgium.

Organizations and persons connected with the project are, the U.S. Treasury, who provide the ten million dollars which must be spent on development and

manufacture of satellites and instrumentation; the U.S. Defence Department, who are giving technical advice, launching equipment and facilities; the Special International Committee of the I.G.Y., whose president is Dr. Sydney Chapman of Great Britain; the U.S. National Academy of Sciences, and the U.S. Science Foundation.

Details of the design of the satellites and the method of launching them will be further discussed at a conference to be held in Brussels later on, but it seems likely that their size and weight will vary with the information they are intended to yield. Different sources mention "as big as a basket-ball," or "19½ in. diameter," or even "a large gas-filled balloon."

Dr. Nicolet spoke of a vehicle roughly 50 cm. in diameter and weighing 50 kg. which would be the pay-load of a three-step rocket designed to carry it into a circular orbit at a height of between 200 and 300 miles. The appropriate velocity and orbital period are 18,000 m.p.h. and 1½ hr. respectively, and the orbit chosen would be one which passed over the North and South Poles. One of its sides would be oriented to face the Sun continuously and it would transmit the measurements it made by an automatic radio link to hundreds of receiving stations, set up in every participating country in the world.

All the authorities discussing the project are careful to stress the spirit of international co-operation, the fact that the programme has purely peaceful intentions, and that the information obtained would be freely available to the scientists of every nation.

The duration of flight of the satellite is a little uncertain, different spokesmen put the time between several days and a few months. Dr. Athelstan Spilhaus of the U.S.A., said, "Even if it only survived for a day or two it could provide valuable scientific data. It is bound to be slowed down somewhat after a fairly short time by the air of the upper atmosphere even though the air is rarefied. The cumulative effect will cause the satellite's orbit to approach closer and closer to the Earth; as it enters the relatively dense atmosphere even some 30 to 50 miles above the surface it will be heated by atmospheric friction until it disintegrates harmlessly."

The satellite should just be visible with the unaided eye near sunrise and sunset; its precise position, velocity and orbit can easily be observed from the Earth's surface. These will be used to amplify our knowledge of the gravitational field of the Earth, in particular the irregularities caused by uneven distribution of its mass. They will also help in geodesy by giving data on the precise relative positions of places on the Earth's surface.

The retardation that it experiences in its passages through the outer regions of the Earth's atmosphere can be obtained from the same kind of observation, and will give comprehensive information on the varying density of the air at different heights.

For these applications the satellite does not need to carry anything more than a surface reflective to either sunlight or radar signals. It will, however, also include suitably designed detecting and measuring instruments, a light-weight transmitter with its information coding modulator, and a power supply, of the sort already used in the high-altitude sounding rockets.

Weather forecasting is one science which will benefit very greatly from the satellite programme. General weather trends are influenced by the Sun in many ways and in particular the effect of ultra-violet radiation is one of the most important. A layer of ozone at about 30 miles altitude absorbs this, and its energy appears as heat in these upper layers of the atmosphere. The intensity of the Sun's ultra-violet radiation, with its variations, may be observed by means of the satellite, and weather changes in the lower atmosphere can then be correlated with such changes.

Other measurements of interest to the weather expert are the reflectivity of the Earth's surface, and the presence and number of micrometeorites. The former is of obvious interest since it tells what proportion of the Sun's heat and light is absorbed by the Earth, and provides the energy for circulation of the atmosphere at low levels. It can readily be obtained by the use of a photocell pointing in the direction of Earth. The latter are minute particles of dust either from interstellar space, or possibly those responsible for the zodiacal light, and are suspected of being a prolific source of nuclei for condensation of rain; a count of their number and size should help to confirm or reject this theory. Radiations and particles arriving from the Sun are also responsible for magnetic storms and auroral displays, the ionosphere, and cosmic-ray showers. It should be possible to solve some of the mysteries surrounding the origin of heavy primary cosmic rays and their effects, and the nature of the charged particles causing auroral displays and magnetic storms. Measurements of the Earth's magnetic field outside the ionosphere will throw considerable light on the source of the Earth's magnetism, and radio signals received from the transmitter will give evidence of the properties of the ionosphere itself.

The great advantage of the satellite is not that it makes these measurements possible, for most have already been the subject of investigation in sounding-rocket programmes, but in the fact that they can be made continuously (and for this reason a circumpolar orbit which would be in sunlight for most of the time has been chosen), and that variation in the different quantities with time can be obtained far more economically than could ever be done with sounding rockets.

Putting the satellite into the sky will probably be done by using the Redstone rocket as the first step, and an Aerobee-Hi as the second. The third step would consist of the instrument container and the rocket motor required to give it the last part of its orbital velocity.

The expected life of a satellite in an orbit at a height of 250 miles is about one year, but a perfectly circular orbit is necessary. If it starts as an ellipse it will, after a few periods, settle down into ever-diminishing circles of radius rather smaller than the minimum radius of the ellipse because of the much more important effect of atmospheric density as the radius decreases. This is, of course, one of the methods proposed for arresting spaceships on approach to planets with an atmosphere, since it implies a reasonably rapid method of losing speed, but in the case of the satellite it means that hard-won rocket impulse is being wasted, and underlines the need for accurate control if a good life is to be attained. Any mistakes, however, will give most useful information for developing approach techniques for spaceships.

A METHOD OF SEALING AND GAS-CONDITIONING AN ORBITAL DUTY SURVIVAL SUIT

By M. C. Paul

SUMMARY

The construction and operation of the Annular Waist Seal are examined together with relevant suit-envelope problems and design. Results derived in the testing of a crude prototype seal are also examined.

A gas-conditioning system is outlined—one permitting a minimum of internal suit apparatus and wiring.

The practical criteria considered are:—high safety-factor, unassisted operation of the seal, a reasonable degree of limb and body movement, the exchange of attached supply units under spacial conditions and the anchoring of safety-lines and propulsion-unit to the suit's exterior.

Introduction

It is almost certain that one of the facets of astronautical research yet to be rigorously pursued will include the development of Survival Suits.

Emergencies arising from actual space-flight will require space crews to operate while wearing survival suits, and a degree of suit flexibility is therefore required as a means of saving lives and equipment. The flexibility of body and limbs can further greatly ease orbital duties, and it is expected that the continued development of high-altitude survival suits in aircraft, will exploit this possibiluty to the full. The choice between rigid or flexible construction, hence the materials to be used in a suit's fabrication, must await further research into cosmic-ray and meteor conditions in the Earth's orbit.[1] The question is complex and at present indeterminate.

Whatever the materials employed, the suit must possess an extremely high safety-factor, as must the seals integrated into its structure. Ideally, the seals should provide a means of rapid ingress and egress to and from the suit. Its occupant is thus afforded a method of survival in all but the worst cases of explosive-decompression or atmospheric poisoning of the personnel chamber. Unfortunately, rapid sealing and a high degree of safety in the process, are conflicting requirements. The problem is further enlarged by the need to permit a man to enter, seal and activate his suit unaided. Laced and zippered seals are proving clumsy, and although metal-gasket seals are in some respects superior, they are subject to severe damage by denting. This is a weakness of considerable importance in orbital operations, where collisions between suit and objects might well be frequent and severe. Large temperature differences across extensive metal unions could readily distort them, a hazard difficult to eliminate in practice.

The seal to be described is an attempt at meeting these requirements, namely—

(1) A safety-factor comparable to that of the suit-envelope.
(2) A means of rapid ingress and egress to and from the suit.
(3) One capable of being operated by a man unaided.

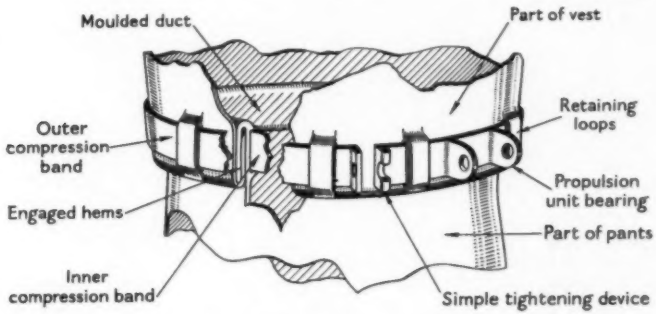

FIG. 1. Principal Components.

By circling the waist region of the suit, the seal divides it into two portions, thereby demanding a minimum number of gas and electrical links across it. A system of atmosphere supply and control that might, with development, meet this condition, is discussed later in this paper.

For the purpose of examining these proposals a flexible suit envelope is assumed. The eventual adoption of a rigid envelope would merely render the integration of the proposed seal a little more difficult, but not impossible.

The Annular Waist Seal

The seal circles the suit-waist, dividing it into pants and vest portions. The envelope, immediately above the seal, is corrugated (michelined) and hooped, thus permitting a degree of body-bending with no appreciable change in the suit's volume. Shoulder, elbow and knee-joints are similarly constructed.

The lower edge of the vest takes the form of a moulded plastic hem, turned inwards, and rising some 4 cms. into its interior. It circles the vest with a diameter that permits this upper portion of the suit to be lowered over the occupant's shoulders. A similar hem is formed by the open end of the pants, but turned outwards. Its diameter is such that it enters the vest as an easy push-fit, the hem's cross-section being shaped to facilitate its entry. This external hem engages with the internal hem of the vest when the pants is slightly lowered. Their tapered edges and flexibility facilitate the action. A moulded annular duct circles the internal edge of the pants, and contains a thin spring-steel band 4 cms. in width, so positioned that its width opposes that of the external hem. A second, thicker spring-steel band circles the vest exterior through a series of moulded loops. When engaged, these hems are tightly sandwiched between the two steel bands by contracting the outer band by means of its clamp (Fig. 1).

It is obvious that, after union, the two suit-sections can move only towards each other, thereby disengaging. Internal suit pressure prevents such movement, forcing the taper-sectioned hems more tightly into contact, thus increasing the efficiency of the seal. The forces acting on the seal components when the suit is pressurized are shown in Fig. 2.

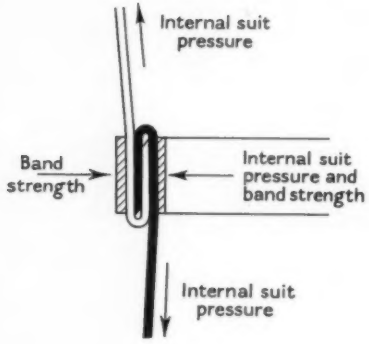

FIG. 2.

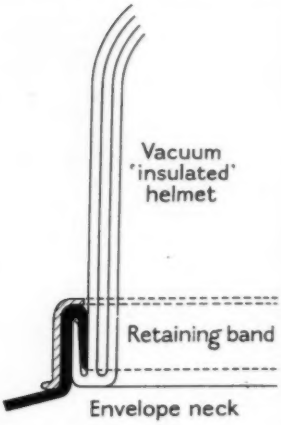

FIG. 3.

Like the envelope, the seal fabric must be resistant to deterioration by water, oxidization, body-acidity and solar radiation. It must also withstand several times the tensile stresses created in it by the internal suit pressure. To meet what is really a minimum specification requires further research. An advanced form of plastic-impregnated, multi-layer nylon weave seems to be indicated.

The seal's operation can best be demonstrated by following the activity of an imaginary wearer as he enters the suit:—

He must hold the vest over his head and shoulders by placing his arms inside and gripping the internal arm entries. As it descends over his body he slides his arms into their respective limb sections, until it rests upon his shoulders. Stepping into the pants he hoists it to his waist by means of a pair of diametrically opposed loops, sited just below the hem. Opposing loops attached to the vest's exterior will then be within reach of his "hands" as they grasp the loops on the pants. Grasping a pair of loops in each "hand" he tightens his grip, thus pulling the suit-sections together. In this process the pants enters the vest. He then pulls on the pants and the hems automatically engage. Their even engagement is ensured by running the "hands" firmly round the seal, after which he tightens the outer retaining band by means of its clamp.

For the sake of clarity the terms "over" and "below" have been used, thus assuming an effective floor on which the preceding operations were performed. However, none of these operations depend upon the assistance of a gravitational field, thus permitting a man to enter and seal his suit unaided under conditions of "free-fall."

Since the suit is relaxed, all the necessary body movements should be easy to perform, including the gripping of the loops by thickly-gloved hands.

Should it prove difficult to ensure proper engagement of the hems during sealing, the vest-hem could become the external, and pants-hem the internal,

components of the seal. This small alteration in the basic design would slightly increase the seal's circumferential length, hence reducing its safety-factor.

Where a separate helmet is used its seal may be of similar design (Fig. 3). This seal requires that the lower portion of the helmet be a right-circular cylinder.

The basic principle of the seal was tested as follows: A large motor inner tube was cut circumferentially about its tubular cross-sectional area. Narrow rings of rubber were vulcanized around the ends of the opened tube, one internally and the second externally, a thin rubber triangle having first been moulded into the wall of one of the ends to slightly increase its diameter. An annular steel band was then stuck to the inside wall of the small end immediately inside the opening. This band was to constitute the inner compression ring of the seal. The tube's small end was then inserted into its larger end and the "hems" engaged. A steel collar was placed over their junction and tightened, thereby sandwiching the "hems" between itself and the inner compression band.

The "remade" tyre was then pressurized to 15 lb./sq. in., and given some general rough treatment. After standing in the pressurized condition for approximately 24 hours, it was given a further period of rough treatment and its pressure measured. Despite the crudity of the seal, there had been a loss of only $3\frac{1}{2}$ lb./sq. in.—a remarkable indication of the potentialities of the engineered product.

A Method of Atmosphere Supply and Control

It is thought possible to supply and control a suit's atmosphere in a number of ways, but it is here necessary to consider one that requires no integrated cooling and heating devices. By so relegating their functions to apparatus within the suit's supply pack it becomes possible to include a number of useful features in the overall design, i.e.:—

(1) A minimum number of gas and electrical links across the seal.
(2) Supply packs can be changed under spacial conditions.
(3) Suit wiring, hence maintenance can be greatly simplified.
(4) All manual controls may be situated on the supply pack.

The basic atmospheric cycle is outlined in the block-schematic of Fig. 4. Within the pack, the stored gas is passed into the cooling or heating units *via* pressure-reducing and control valves. Here its temperature is brought to a predetermined level—40°/45° F. It is then sucked into the suit neck and directed upwards into the front of the helmet. This occurs at suit pressure—up to 10 lb./sq. in. The mixture of unused and exhaled gases is drawn from the helmet into the suit's body, and from there, into the limb sections. A small gas pump within the pack extracts the mixture of gas, water vapour and body odours from the limb extremities, *via* toe and fingertip orifices, along a system of ducts. These ducts are moulded on to the exterior of the envelope and are duplicated where they traverse the suit joints. In this manner one duct is always free to pass the extracted gases on to the pack. On entering the pack the mixture passes to a series of units which removes from them excess water, carbon dioxide, body odours and acidity. The unused oxygen, and possibly helium, is then injected into the primary gas supply for re-use.

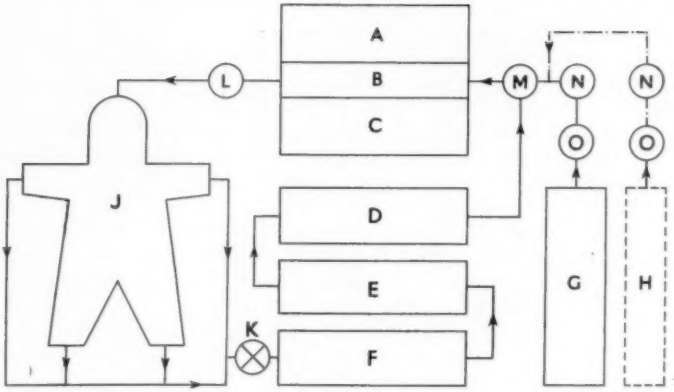

FIG. 4.

A. Cooling unit.
B. Temperature control unit.
C. Heating unit.
D. Unused-gas cleanser.
E. Carbon dioxide remover.
F. Excess water remover.
G. Oxygen storage cylinders.
H. Helium storage cylinder.
J. Survival suit.
K. Gas circulating pump.
L. High-pressure relief valve.
M. Recycled gas injector valve.
N. Manual "flow and stop" valve.
O. Pressure reducing valve.

Unless extended periods are spent within the Earth's umbra, the gas temperature throughout the suit's body will be determined, effectively, by the reflectivity of its outer surface and heat generated by the occupant's body. Since it is possible to make the outer surface of the envelope reflect from 70 to 80 per cent. of incident solar radiation, internal body heat will determine largely the degree of gas cooling required.[2] A thermostat, preferably duplicated, within the suit-body would monitor the temperature control units, thus correcting fluctuations in the mean level, such fluctuations would occur as the envelope area presented to the Sun varied, as the suit's orientation changed.

The heating unit would only be required to operate during extended periods of duty within the shadow of Earth or of a large object in the orbit. The rapid, large changes in temperature associated with entry or emergence to or from extensive shadow, would be slowed by the gas-flow over the body, which would act as a "thermal-cushion." The corrective action of the temperature control units could thus be gently applied, thereby eliminating the unpleasant prospect of receiving hot or very cold gas streams into the suit.

Several hours of continuous operation makes the decomposition of carbon dioxide and the storage of extracted water for drinking, desirable features of the suit. These additional functions enlarge the already strenuous demands upon the supply pack, and may be omitted from prototype suits.

The schematic design in Fig. 4, and its description is but an outline of a potentially useful system. In this and all others, the detailed design and function of the various units must be relegated to the specialists in their respective fields. The cooling unit and primary power source present designers

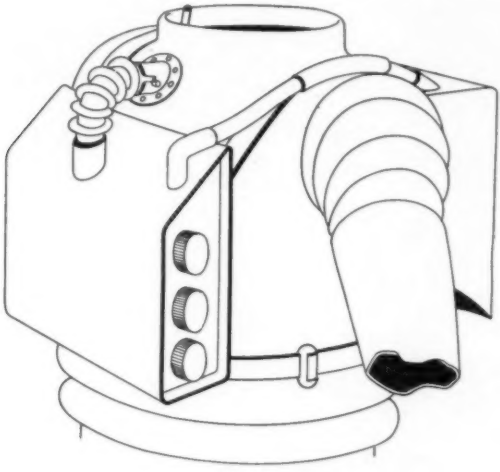

FIG. 5.

with some difficult problems. The latter is the more acute and its only known solution attends batteries of secondary cells and their future development. The theoretical possibility of festooning a suit with a complex system of Silicon/Boron crystals, or solar generating gear, is singularly unattractive. Thanks to batteries, be they lead-acid or nickel-alkaline (preferably the latter), the supply pack will be extremely bulky. It is therefore reasonable to consider the splitting of the pack into two interconnected sections. These could be "hung" over the suit's shoulders and fastened to its waist (Fig. 5). All controls other than presets, including those of the suit's radio, could be arranged on the sides of the front section, there being in reach of the "hands."

Fig. 5 shows only one hose coupling pack and suit. It conducts the gases to and from the suit and comprises two concentric flexible tubes. These are terminated in simple non-return valves. The suit-hose union is terminated by a strongly-sprung disc seal which only permits the flow of gases to and from the suit after the hose has been fully inserted and locked. This system is straightforward and allows the pack to be changed under spacial conditions. There would be sufficient oxygen, at adequate pressure within the suit to permit a short interruption of the gas-flow. A period of 30 seconds would suffice, providing the replacement pack was ready for immediate connection.

The wiring to the suit's internal thermostats and pressure monitors could be connected to the pack *via* a system of robust contacts on the union and hose. Microphone and headphone leads could be similarly arranged.

Some General Considerations

In any attempt to examine the overall effect of a fundamental design change, all principal requirements of the artifact must be considered. The change of

type and location of a seal for a survival suit is such a design change. It is of no use providing a quick-action seal, etc., if in so doing it becomes impractical to attach safely to the suit safety lines and propulsion motor. These and some other factors associated with the proposals outlined above will therefore be briefly examined.

The seal's outer compression band can be given a temporary elliptical configuration without impairing its efficiency. Its total, possible, movement is limited by its close proximity to the occupant's body, hence no serious distortion of the surrounding envelope can occur. The centre of the circle it describes is also quite near the centre of gravity of the suit-man combination. It is easily accessible. This band therefore provides an ideal anchorage for safety lines, propulsion motor and tools.

A weakness of single-walled envelopes is their ability to conduct the 20 to 30 per cent. unreflected solar heat to the suit's interior. It is therefore undesirable for the occupant's skin to come into contact with the envelope at any point. The complete solution of this problem entails the use of double walls and vacuum insulation. However, with an extremely high surface reflectivity approaching 90 per cent. single-walled envelopes might possibly be retained and the occupant's body and limbs covered by a one-piece coverall of closely-woven cotton or linen.

It is possible that the highly polished envelope would frequently chafe against objects in orbit, and it appears to be desirable to provide it with a thin, tough and shaped drape. Such a "chafing-sheath" could also be polished thereby assisting reflection of incident radiation. It would be removable and replaceable. In the waisted suit this sheath would be in two parts, each loosely attached to its envelope component.

Acknowledgment

The author is grateful to Mr. H. E. Ross for his study and comments upon the fundamentals of this paper.

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(1) S. F. Singer, "Research in the Upper Atmosphere," *J.B.I.S.*, 11 (2), p. 70.
(2) A. C. Clarke, "Temperature of a Body in Space," *Interplanetary Flight* (Mathematical appendix), p. 158.

INTERPLANETARY FILM STRIP

The Society has now prepared, for the benefit of lecturers, a 35 mm. film strip containing 50 pictures showing modern rockets, orbital satellites, spacesuits, spaceship designs, and astronomical subjects. This strip will be invaluable not only to speakers wishing to address organisations of any type, but also to those wishing to have a private collection of rocket and space-flight pictures. If a projector is not available, the strip can of course be examined by one of the 35 mm. transparency viewers obtainable at any photographer's.

The cost is 10/- per strip, post free, which works out at the modest sum of 2½d. a picture. Orders should be sent to the Secretary at 12, Bessborough Gardens, S.W.1.

THE RADIO EXPLORATION OF SPACE

By R. C. Jennison, B.Sc., Ph.D.

SUMMARY

The general principles and applications of radio astronomy are outlined, and reference is made to the various types of radio telescope at present in use. A short account is given of the detection of meteor activity, the aurora, and the moon by radar techniques, whilst the remainder of the paper describes the various aspects of radio astronomy associated with the emission of radio noise.

Introduction

Radio astronomy, although it has only really developed during the last decade, has already made considerable contributions to our knowledge of the Universe. It has opened up a vast new range of the electromagnetic spectrum, many octaves broader than the narrow visible band to which previously Man's research has been confined. Many objects which to visual astronomers appear very faint and often invisible, even with the great 200-inch telescope on Mount Palomar, emit so strongly in the radio frequency spectrum that they are detectable with the most elementary apparatus. Furthermore, the vast clouds of dust which obscure so much of the Galaxy on optical frequencies do not seriously attenuate radio waves, and these hitherto inaccessible regions are now open to investigation. Away from our own Galaxy many of the most distant extragalactic systems emit so strongly on radio frequencies that if we assume that some of the weaker radio sources are also objects of this type, they must lie far beyond the limit of the visually observable universe.

Included under the general title of Radio Astronomy there is a somewhat different line of investigation which may be considered as Radar Astronomy. This subject covers all those researches concerned with the application of radio echo techniques to the observation of meteor trails, the Moon, and the Aurora Borealis. Radio echo techniques rely upon the reflection from the body under investigation of the radio waves transmitted from a station situated on Earth. This implies that the power received back from the body decreases as the fourth power of its distance from the transmitter, and therefore the method is restricted to nearby celestial objects. Radio echoes from the neighbouring planets are not possible with existing radio telescopes but it is hoped to obtain echoes from Venus with the 250-feet radio telescope now under construction at Jodrell Bank. The energy reflected back from an object also depends upon the shape and size of the object, and for large objects of similar shape but different size, the reflected power is proportional to the area presented to the observer. It will at once be apparent that a man-made missile of even the most gigantic proportions will be out of range of present day radar long before it reaches the Moon.

Radio telescopes may assume all shapes and sizes, ranging from the giant parabola under construction at Jodrell Bank, through the twin aerial and multiple aerial interferometer systems, to the relatively small arrays used for solar and meteor investigations. Some of these smaller aerials used for constantly monitoring the activity of the sun are no more than simple dipoles and reflectors, just like ordinary television "H" aerials. The larger aerials

are used where it is necessary to have a higher gain, for example, to detect or study very faint radio stars, or where it is required to determine the accurate position of an object. These two properties of a large collecting area usually go hand in glove, but it will be apparent that if one wishes to determine the position of a source accurately in one direction only, then one may use an aerial in the form of a long thin rectangle; in these circumstances the gain and the collecting area will be small, but the resolution in the direction of the long axis will be considerable. The principle of obtaining very high resolution without the trouble and expense of constructing an enormous aerial is most beautifully demonstrated by the interferometer type of radio telescope, in this case the telescope simply consists of two small aerials spaced apart by a considerable distance, say half a mile, but connected together by coaxial cable or open wire feeders. This arrangement actually gives double the resolution of a complete line of aerials extending for the whole distance between the original pair, but again it is at the expense of collecting area and therefore sensitivity.

Just as an optical telescope may be connected to a spectrometer, a camera, or a photo cell, so a radio telescope may be connected to a variety of different electronic instruments. The basic arrangement is to record the total power emitted over a certain frequency band, the aerial is connected to a receiver having a square law detector, and the output of this detector is used to drive a recording meter. The greatest difficulty lies in the fact that the signals are usually so faint that the noise contributed by the receiver itself is far greater and the situation is rather like trying to see a faint star in daylight. Various techniques have been developed which enable the equipment to respond only to the excess radiation of the star above the background noise both of the receiver and of the Galaxy in general, and these methods have now largely supplanted the original technique. The radio telescope may be connected to a radio spectrometer for the investigation of the hydrogen line radiation from the interstellar gas in our own Galaxy. This device usually consists of a radio receiver which measures the difference of intensity of the radiation on two different frequencies spaced about a megacycle apart, whilst both frequencies are moved together through that part of the radio frequency spectrum where the radiation from the line is expected to occur, this frequency is under normal circumstances 1,420 Mc/s.

There are two applications of the radio telescope in which it differs widely from conventional optical telescopes. In the first of these the output from the telescope is multiplied with that from another telescope, often of very different shape and design, to give a variety of reception patterns and other properties which are impossible to obtain with visible light. Radio frequencies, unlike optical frequencies, may be simply changed in frequency whilst retaining phase coherence, and this is the basis for many of the conjuring tricks performed by the radio astronomer. The other application in which radio telescopes are used in an entirely different manner to ordinary telescopes is in their adaptation for radar or radio echo techniques. In this case the telescope is effectively used at one moment as a searchlight to illuminate the object under investigation, and a fraction of a second later it is converted into a conventional

telescope or receiving aerial to collect and measure the radio waves scattered back by the object.

Applications of Radar Astronomy

Radar astronomy has been applied to the study of astronomical phenomena in the immediate vicinity of the Earth, and in particular to the observation of the Moon, the aurora and the meteors which enter the Earth's atmosphere. Radar echoes from the Moon require a transmitter operated at a mean power of about a kilowatt and pulsed to give a burst of radio waves lasting for about a millisecond once every three or four seconds. The echo returns from the Moon after about three seconds and may be displayed on a cathode ray tube or, if desired, listened to and recorded for future study. It is found that the intensity of the echoes received is most inconsistent both over very long periods and from pulse to pulse. The very long period fading, sometimes lasting many hours, is due to the effect of the Earth's ionosphere; in all the experiments that have been made so far the signals have been sent out from the Earth in one plane of polarization, the effect of the magnetic field of the Earth on the ionized gas in the upper layers of the Earth's atmosphere is to rotate this plane of polarization several times, so that the echo received back from the Moon is liable to have any arbitrary polarization. If the echo returns with a polarization at right angles to that transmitted the aerial system will fail to receive it and no echo will be detected. The answer to this difficulty, which would also cause trouble in communicating with spaceships, is to use for both the receiving and transmitting aerial a system which is circularly polarized, such as a helical antenna. The fast fading on the lunar echoes results in a quite unpredictable level of the received signal from pulse to pulse, very often for periods of about half a minute no pulses at all are received, a moment later they may appear at full intensity. It has been shown that this fast fading may be explained by the effect of libration.

The ability of meteor trails to reflect radar pulses relies on the fact that the meteors, on reaching a height of about 100 kilometres in the Earth's atmosphere, produce columns of ionized gas due to the velocity with which they collide with the atoms of the tenuous atmosphere. The ionized column left by a meteor acts as a metallic conductor whose length increases as the meteor moves on, and this fact is of considerable use to radio astronomers for it causes the efficiency of the streak as a reflector of radio waves to go through a series of maxima and minima as the length of the column extends over successive Fresnel diffraction zones. There are a number or techniques for determining the radiants and velocities of shower meteors by radio methods, and more recently methods have been devised for the determination of the same parameters in the case of individual or sporadic meteors. In short, this research has shown that there are many more meteor showers than had previously been suspected, especially heavy daytime showers, and that there are very, very few meteors with hyperbolic velocities—meteors from outer space. The speed and manner in which the meteor trails diffuse soon after formation yields information on the winds blowing in the atmosphere at a height of 80 to 100 km.

Winds in the atmosphere at a much greater height, between 200 and 400 km. may now be determined by a quite different radio astronomical technique. This method determines the motion of inhomogeneities in the upper ionized layers by recording the scintillations of radio stars at a number of receiving stations spaced a mile or so apart.

The aurora borealis gives a clearly visible radar echo of a persistent character. Measurements may be made of the extent, distance, and motion of the aurora, as well as such parameters as the electron density, pressure and temperature. Recent measurements have shown that the aurora may extend for well over 1,000 miles following the lines of geomagnetic latitude.

The Radio Sun

The Sun is the only true star yet known to emit radio waves. These solar radio emissions may be categorized as the radiation from the "quiet" Sun, the radiation from sunspots, and the radiation from solar flares and outbursts. The radiation from the quiet Sun, that is the undisturbed solar disc, is not as intense as that from the Galaxy in general, but is somewhat greater than that from the individual "radio stars." The apparent size of the Sun's disc depends upon the frequency of the radio waves received, at centimetre wavelengths it is the same order as the optical size, whilst at ordinary short wavelengths it is two or three times as large. The radiation here comes from the corona and the measurements have contributed a great deal to our knowledge of this outermost part of the Sun. The radiation from sunspots is of a somewhat different character, it is circularly polarized, very irregular, and much more intense. The most powerful of all these solar radio signals come from the solar flares or outbursts, like the radiation from the quiet Sun these signals are randomly polarized and the source of the radiation may be shown to move out from the Sun's surface along with the visible flare. The solar outbursts often produce a sequence of additional phenomena which may be detected by radio methods. The immediate effect of the flare is to produce a flash of ultra violet light which suddenly increases the ionization of the Earth's upper atmosphere and causes a radio fade-out. The ionosphere soon recovers, but about 24 hours later the Earth's ionosphere is again wrecked; there are severe radio fade-outs, magnetic storms and aurorae. These phenomena have been explained as due to a neutral stream of charged particles emitted from the Sun at the time of the outburst at a velocity of about 1,500 km./sec. In a recent paper the author showed that the effect is more probably due to an intense shock wave moving out through the extreme outer corona of the Sun well beyond the Earth. Such a shock wave would account for the sudden commencement of the effects on Earth, whilst a velocity of 1,500 km./sec. for the shock front would enable it to sweep up and ionize most of the atoms of gas in its path.

Galactic Radio Sources

The earliest experiments in radio astronomy showed that a large amount of energy was radiated from the Galaxy in the radio frequency spectrum. This radiation may be considered as that from small sources, or radio "stars,"

in the Galaxy, together with the irresolvable radiation from the Galaxy itself. In both cases the radiation increases as we observe on longer wavelengths, but in the former case less rapidly than in the latter. All the more powerful radio sources have been found to lie in the Galactic plane and it is thought that they may be the remnants of supernovae, that is, stars which exhausted their supply of hydrogen and exploded centuries ago. An example of this sort of radio star is the Taurus source, identified as the Crab nebula, a supernova which was observed by the Chinese to flare up and explode in the year 1054 A.D.

The radio star Cassiopeia I lies in our own Galaxy. It is the most intense of all radio stars, and at a frequency of 81 Mc/s. it has a flux of $2{\cdot}2 \times 10^{-22}$ watts/metre^2/cps. Though it was once thought that this object was of extremely small angular diameter and might even be of stellar dimensions (hence the original title of "radio star"), measurements have now shown that it has an angular diameter of five minutes of arc and is roughly circular. Though previously visual astronomers had not been able to locate any unusual astronomical object in the position of this or of any other radio star (except Taurus) a long exposure photograph with the 200-inch telescope at Mount Palomar now showed that in the light of a red filter the whole area of the radio source was covered with a number of short faint filaments. Spectroscopic examination of these filaments showed that they had internal velocities ranging from 1,000 to nearly 5,000 km./sec. The object was quite unlike any other astronomical body that had previously been seen. Though some astrophysicists believe that it may be a most unusual manifestation of an old supernova shell, the true interpretation of this object is still a conundrum.

Subsequent to the identification of Taurus and Cassiopeia, a few other radio sources in the galactic plane have now been identified. Many of these sources are of large angular diameter and all show signs of gas in violent motion; photographically they are all very faint and diffuse.

The Hydrogen Line

Quite apart from the radiation from the radio stars and the background radiation of the Galaxy, both of which are spread over many octaves of the radio frequency spectrum, there is a monochromatic signal emitted by the tenuous interstellar gas. This signal is generated by a reversal of the spin of the neutral hydrogen atoms, and under normal conditions it has a frequency of 1,420 Mc/s. When, however, the source of the radiation is moving, the signal may be shifted in either direction from its nominal frequency according to whether the motion is towards or away from the observer. This phenomenon, which is, of course a Doppler shift, enables the radio astronomer to map out the motion of the neutral interstellar gas, and in particular to determine the position of the vast spiral arms of our Galaxy, even where the stars are completely obscured by dust clouds.

A more recent application of the hydrogen line has been to use the absorption, by the hydrogen atoms on this frequency, of the radiation from the radio stars, to determine the distance of these stars from the observer. By determining the intensity of the radio star both on and off the frequency of the hydrogen line, and by determining the intensity of the hydrogen line

radiation at a position slightly away from the star, it is possible to estimate with reasonable accuracy the distance of any source within our own Galaxy. In the case of extra-galactic sources we can only show that they must lie outside our own Galaxy, as inter-galactic space is practically devoid of gas.

Extra-Galactic Radio Sources

Beyond the realms of our own Galactic system it is found that the nearer of the structurally similar extra-galactic nebulae, such as the spiral nebula M31 in Andromeda, radiate an extended radio frequency spectrum of total intensity roughly equal to the integrated radiation of our own Galaxy. This result is important, but not surprising, for it confirms that our Galaxy is not unorthodox but generally resembles millions of others distributed throughout the whole expanse of the Universe.

Many of the more intense radio sources which, by reason of their spherical distribution all over the sky, are inferred to be extra-galactic objects, appear to originate where there is no visible nebula, or where such a nebula is photographically very faint. When, however, the photographs of these very faint nebulae are carefully examined, it is found that they are very peculiar objects showing remarkable structure and strong forbidden emission lines. The clue to a correct interpretation of these objects was provided by the second strongest of the radio sources, the radio "star" Cygnus I. Long exposure photographs with the 200-inch telescope brought to light a nebula of 18th magnitude in the position of this source. This nebula, which exhibited the unusual characteristics just described, has been interpreted as the collision of two great spiral nebulae. These two great systems, each like the Andromeda nebula or our own Galaxy containing hundreds of thousands of millions of stars, are colliding face on at a speed of about 5,000,000 miles per hour! Although there are so many stars in each system most of them escape collision for the spaces between them are so great. Distributed in the space between the stars there is, however a very tenuous gas, which, although it has a mean density of only about one atom per cc., that is about 10^{-19} the density of air, is sufficiently dense to ensure that it undergoes a complete collision. If we remember that the total quantity of this gas in each Galaxy is at least equal to the total mass of the stars, we realize that we are witnessing a catastrophe of incomparable magnitude that will result in the birth of a new galactic system.

DISCUSSION

Opening the discussion, MR. P. MOORE complimented the speaker on having given what was undoubtedly one of the best lectures the Society had ever had. He asked what effect the lunar librations had upon radio echoes received from the Moon. DR. JENNISON replied that the observed fast fading was just what would be expected, but that a more detailed study would be the subject of one of the first experiments to be done with the new radio telescope. MR. MOORE asked whether he was satisfied that there was a definite effect, and DR. JENNISON replied that there was a polarization effect; but another effect, that of the Doppler shift, was of the second order of

magnitude and would not be easy to find. One has to measure a slight change of frequency, using an extremely narrow band.

MR. G. V. E. THOMPSON asked what was the duration of a collision between two Galaxies, and DR. JENNISON replied that it was of the order of half a million to two million years, unless they collided exactly flat on, in which case it would be of the order of 100,000 years. On recent photographs by Zwicky one can see that two Galaxies are just separating after a collision, because there are still a number of filaments joining them.

MR. THOMPSON also asked what was the minimum size of an object at planetary distance from which reflections could be received. DR. JENNISON said that nothing smaller than Venus would theoretically give a detectable echo at that distance. To a question whether the distance of the Moon could be found more accurately by radio echoes, he replied that it could be done theoretically but the method was not at present practicable.

One questioner asked whether the speaker would not do better to take a radio telescope to the Moon, but DR. JENNISON thought not. It was easy to see (by radio) through the ionosphere in the vertical direction, and the Earth's atmosphere does not worry the radio astronomer as much as the visual astronomer; in fact, one can "see" a radio star in the daytime and in thick fog, and the ionosphere never causes much restriction.

To a question about the size of beam used, DR. JENNISON replied that it varies according to what one is looking at. The width might be as much as 45° when examining meteor showers or the aurora, but for radio echoes from the Moon, the smaller the better. However, the narrower the beam used, the quicker the Moon passes through it and the less time there is for observation. For radio stars the beam is usually quite narrow—½° for the highest frequencies and 2° for the usual frequencies; they hope eventually to use a width of 5–10′ of arc. For interferometry, when two telescopes are used connected by a base line, a width of seconds of arc can be used. As to the frequencies used, the strength received from a radio star increases with decreasing frequency but the galactic background does so even more.

A questioner asked whether "dark stars," such as the companion of Sirius, were radio emitters. DR. JENNISON replied that there are probably more white dwarfs than any other kind of star, as they are so faint; the more we look for them the more we find. But in any case the Sun is the only star near enough for us to detect its radio emissions.

Answering another question about galactic collisions, DR. JENNISON said they were waiting for the astrophysicists to work out the gravitational pull between approaching Galaxies; it may well be that the centres pull together and collide first. Radio emissions would be received from the outer rings colliding after the nuclear areas have done so. Another question was whether, if two approaching stars do not collide, the planets going round them would nevertheless be carried off, but DR. JENNISON said it seems on investigation that planets would tend to stay with their parent star.

Radio astronomers, DR. JENNISON said in reply to another question, think it possible that formation of the solar system was due to a supernova, but they will not commit themselves at present. Apart from the novae known to

history, there must have been nearer ones in the past, the tenuous remnants of which are still entering the solar system.

To a question about meteors, DR. JENNISON replied that sporadic meteors have been studied carefully for the last seven years, but it was not known until recently whether they came from outside the solar system. We now have a record of one meteor with a definite hyperbolic orbit which must have come from outside, and three doubtful cases whose orbits were only just hyperbolic. If we were running into this meteoric dust it would tend to be accreted in our wake and we would expect to get radio signals from it, but we do not. Pure gas colliding at high velocity would give out strong radio emission.

A. E. S.

SOME POLITICAL IMPLICATIONS OF SPACE-FLIGHT

BY A. W. B. HESTER

SUMMARY

A case is presented for international control of astronautical experiments and future operations. The political aspects of this science extend beyond national policies. Long-range, high altitude experiments will inevitably bring encroachment of territorial rights (as at present defined), to endanger life and property and become an issue of international contention and a threat to world peace. A basis for United Nations Organization control is formulated.

Politics and Astronautics

Undoubtedly there is now widespread acceptance of the inevitability of space-flight, for astronautics now contains a sound basis for the design of satellite vehicles and outer space rockets, and it follows that such projects should be related to a clearly defined national policy for the purpose of co-ordinated scientific investigation by government establishments, interested industrial organisations and associated scientific bodies. In these times of strict and essential security this may well be the policy already adopted but this present article is written in the absence of evidence of any official policy. Inevitably, subsequent development for purposes inter-relating purely scientific aims with national aspirations, whether of beneficial or ill intent, must lead to international problems. Within this broad conception significant political implications are worthy of examination, for these problems cannot be disregarded, irrespective of the nation which gains this particular form of superiority.

The political impact of successful space-flight will be global and clearly demands an early examination of the dangerous potentialities that must arise from the outset. The United Nations Organisation is logically proposed for such action although it could be initiated by one or more of the greater powers. There can be little hope of any advance from action taken through normal diplomatic exchanges, for well-founded fears or predictions of disaster do not necessarily move governments to seek agreement.

Why then should agreement be sought on such an apparently abstract

matter as space-flight, when more readily understood, and far less complicated, issues remain insurmountable? The question is a reasonable one.

For example, ordinary people find it difficult to understand the seeming deliberate obstinacy shown by major powers over international atomic control yet none fail to recognize the dangers which dog humanity and provide a common ground upon which agreement should be achieved—the will and right to survive. A fundamental cause of failure to agree is the belated tackling of grave international problems when they have gone beyond the stage of control or easy compromise. Therefore, astronautics should be considered objectively with a view to international control, at the risk of appearing premature and certainly in the face of scepticism.

This may well seem prosaic moralizing, smacking of over-simplification and labouring the obvious; equally the mooting of these problems may be regarded as their creation. Over-simplification is a serious fault and, to avoid criticism, it should be understood that there is no simple solution in dealing with problems the solution of which rests in the embodiment of differing opinions, objections and demands from nations of different political administrations.

If we accept the cause of failure to agree as delay in examining international problems, it will be recognized that delay is caused by jealously guarding any scientific progress which affords strategic advantages, e.g., as in the case of nuclear weapons. Whichever nation tries to seek international agreement in astronautics must face the challenge of another (or others), but only if the opposer has gained an advantage by which the remainder can be dominated. That is the situation which U.N.O. must seek to avoid—not a hypothetical circumstance, but a definition of a common attitude of a dominant power and an objective view of the future.

However, recognition of obstacles cannot reduce their importance nor simplify the manner and means by which they can be resolved. Agreement in principle as a political nicety is relatively easy to obtain, resulting in the limited exchange of valueless, out-dated technical data. Unfortunately these superficial gestures do nothing but cloud the ultimate aim and tend to limit the confidence required to allow the free inter-change of information bringing lasting beneficial results by co-operation; allies are blatant non-confidents.

Emphasis on the military importance of space-flight is not made here, nor is it intended to elaborate strategic advantages or fantastic probabilities. Rather than encroach on the imaginative field of science-fiction, it is mentioned here only to underline the inescapable political problems. If reference to pure politics is necessary it is sufficient to reflect on the fact that national policies must, as they already are, be increasingly subject to broader issues determined by international collectivity within U.N.O.; astronautics is but another social issue.

Evidence for Control

What is the astronautical picture internationally? On what evidence are the opinions here given? To the first question the answer is simple—the official programmes for astronautics in any country are conspicuously absent. The answer to the second question is also simple, if unconvincing—there is

little evidence beyond that contained in the works and lectures of scientists and in a few press reports and broadcasts. Nevertheless such limited evidence permits safe conjecture and by no means reduces the substance of the case for international control of this science.

During a Moscow broadcast a scientist gave a broad picture of the Soviet attitude towards the future of space-flight. A press report of the broadcast, although taken out of context, indicated that the speaker regarded astronautics as a serious science and appeared to have definite ideas on the trend of development. First, an extension of velocity, range and altitude of rockets allied to guided, long-range offensive missiles, then the orbital rocket (artificial satellites would logically follow), the Moon circling radio-sounding spaceship, and, ultimately, manned spaceships. From this overall conception can be recognized—even with deductions of propaganda values, some serious endeavour in the U.S.S.R. to advance in this field. This is no less sobering than reflections on nuclear experiment possibilities.

In America and Britain limited disclosures have been made with respect to recent guided missile development and some information has been provided to indicate what is intended in astronautical development. From America comes a White House statement that, within three years, an artificial satellite globe, equivalent in size to a football, will be projected to orbit at 250 miles and is intended to close into the Earth's atmosphere and disintegrate as a meteor. This points to a danger inherent in such experiments—the indeterminate location of descent. There are also reports of the Atlas inter-continental missile to be fired into space, achieve 18,000 m.p.h., and which could carry a hydrogen bomb warhead and reach an objective thousands of miles distant. A recent press report of British plans by the chairman of the British Royal Society, Professor H. S. W. Massey, reveals a limited Britain-Australian programme for upper atmosphere research; apparently Professor Massey knew of no plans for satellite experiments.

To enable a better appreciation of the case for control it is essential to define certain specific problems, other than those of military significance, closely related to the hazards arising from what must become normal space-flight operations; the problems are simple in cause and definition.

Initial astronautical experiments must be conducted so that the missiles of limited range and duration return to Earth, and in each and every experiment is an inherent hazard. What freedom is permissible and what limitations are to be imposed to avoid accidents in populated areas?

Our world, ever shrinking when measured by time separation rather than geographical distance, becomes an increasingly restricted field over which remotely controlled, unmanned missiles can travel at tremendous velocities which disregard national frontiers. Such experiments could cause incidents to menace an uneasy peace. Little imagination is required to visualize the consequences of a large missile, carrying many tons of propulsive fuel, landing in a large town, a seaport, or village, meeting an air-liner in flight or colliding with an ocean-going liner. This is the type of threat from projectiles not comparable with the immense ships which will eventually be employed in serious space-flight trials.

Guided weapon development, the chrysallis stage of space-flight, coupled with nuclear weapons, is being pursued vigorously and, as velocities and ranges increase, the location of test areas becomes a subject of increasing concern. Already fears and objections have been expressed, since the radio-active effect of vast nuclear experiments cannot be contained within precisely defined areas. Contamination of territorial waters and the atmosphere have caused disquiet, not only among those who live in relative proximity to the tests, but also among medical men and scientists who are generally reluctant to hinder a new science by airing opinions that might breed prejudice. Assuming atomic power is to be adopted for large rockets, the problem of infringing territorial skies must create misgiving for it will be impossible to avoid overland courses during ascent or descent.

On the assumption that experiments in the near future are to produce ever-increasing hazards it is prudent and natural to attempt to eliminate or at least, minimize the consequences. It might be argued that meteoric collisions with the Earth, being unpredictable and numerous, are more threatening than the possibility of the more predictable man-launched rockets landing in populated areas. No one loses sleep over meteors, but the weakness in the analogy is that these Acts of God are beyond misconstruction in political terms. *Any* missile landing in foreign territory, even if no damage is caused, could cause trouble. Every long-range missile—i.e., any missile with a range extending beyond the limits of national origin, must be regarded as a threat to international peace.

Opinions—Public and Political

This not-too-distant threat (which some may dismiss as fanciful) poses the case to be argued on the grounds of necessity. The wisdom of engaging in ambitious, expensive and, to all intents, non-productive projects, is open to question, for any progressive step in science is at some time opposed on one or all of three issues—moral, economic and political. Despite the widespread acceptance of the certainty of space-flight within the next decade, opposition is inevitable. Opposition from the public may arise from fear of the hazards, the military potentialities and, the affect on taxation by the tremendous expenditure involved. Public opposition may not easily be overcome, for the conflict of opinion may germinate the seeds of dangerous political exploitation, as now seen in the nuclear bomb controversy. Politicians, sincerely or otherwise, will not ignore the public conscience and cannot avoid being embroiled in the camps of ayes and noes. Challenges against the large appropriations, necessary for any worth-while project, will be loud and strong and the magnitude of these appropriations must, of course, be determined by the prevailing economic conditions. No tax-payer, unless acquainted by a knowledge of the real values of research, can look back in regard to the "Brabazon" and "Princess" with anything but regret for the great cost involved. Opposition has, not unnaturally, grown against "white elephant" projects where the cost involved is irrecoverable, thus making serious research appear extravagant scientific adventures.

Formula for Control

No matter how strong the opposition, the achievement of space-flight will be realized. Although these present views omit the scientific problems of space-flight and emphasize issues which may seem irrelevant and superfluous to the serious scientist, proper control is essential to national and international security without impeding development. It is believed that international control can, in fact, accelerate development. Accepting international agreement for control of astronautic experiments and development, U.N.O. should draft a plan offering a basis for exploratory discussions between immediately interested nations. Such a basis could be formulated from:—

(*a*) Acceptance of the inevitability of space-flight.
(*b*) The acceptance that space-flight is a medium enabling a single nation to threaten all others.
(*c*) Recognition of the hazards to persons and property and the necessity to control and place limits on astronautical and long-range missile experiments.
(*d*) Determination of a unified policy to embrace all nations to ensure the practical and beneficial application of astronautics.

From these fundamental points a conference could proceed to resolve in reasoned anticipation, conflicting opinions and define co-operative aims, eradicate suspicion and allay fear in the mind of mankind by restriction or prohibition of the military application. Idealistic hopes as these cannot be compared favourably with the realism of dogma and avowed disagreement associated with recent international conferences. The difficulties are manifest and the conference envisaged would be protracted, but under no circumstances valueless.

A closer examination of the broad issues reveals several thorny problems enumerated below:—

(*a*) Constitution of the U.N.O. commission for the co-ordination of research and development of astronautics.
(*b*) Methods for pooling information and the interchange of scientists and technicians.
(*c*) Freedom of international development and limitation of private ventures.
(*d*) Control and co-ordination of operations. Under this consideration would be taken schemes for notification of countries to be traversed. Details would include trajectory, velocity and duration for outward and homing flights.
(*e*) Methods for the reduction of operational hazards. Necessary restrictions and precautions would cover limitations of flights within defined territorial atmosphere, pole to pole sea traversing trajectories from ice-cap fringe bases, barometric control for systems and introduction of safeguards against radio-active contamination.
(*f*) The prohibition of war-head explosives and destructive material other than propulsive fuels.

(*g*) Agreement on joint action by U.N.O. against a defaulting nation. Such defaults might be:—

(1) Mis-application of astronautics for military purposes.
(2) Refusal to disclose information within the terms of the internationally agreed policy.
(3) Deliberate violation of a foreign territory by disregard of internationally agreed safeguards and procedure.

Clearly the path to agreement is strewn with obstacles, but nothing can be achieved by attempting to prohibit development. Astronautics promises unprecedented discovery and frightful, far reaching exploitation, bringing benefits of unimagined value or disasters of great magnitude. No matter what fears or hopes arise, astronautics cannot be limited. Earthbound man stands on the threshold of a new age of discovery. With the development of space-flight exploration this new science can and should afford a greater understanding and cohesion to our earthly nations as man realizes his insignificance within the Universe.

THE VOLCANIC THEORY OF MARTIAN GREEN AREAS

By A. E. Slater, M.A., M.R.C.S., L.R.C.P., F.R.Met.S.

A new suggestion to account for the dark areas on Mars was discussed in *J.B.I.S.* for March-April, 1955[1]; it had been put forward by Dean B. McLaughlin of the University of Michigan Observatory,[2] and was to the effect that these areas consisted of mineral matter drifted by the wind from sources which he suggested must be volcanoes. McLaughlin has now elaborated his ideas in two further articles.[3,4] It should be emphasized that he is not dogmatic about his theories, especially when he goes into details, but considers that they are plausible enough to be taken seriously as a possible explanation of the dark areas, particularly as the attempts to explain them as vegetation have encountered certain difficulties.

Martian Wind Systems

McLaughlin's first point, which in fact set him going along his present line of thought as far back as 1939, is that the shapes of many of these areas repeat themselves around the Martian globe in a parallel manner, and that they are elongated in the direction of the probable winds, particularly winds of the kind known as "trade winds" on the Earth.

Trade winds can be regarded as caused by a constant flow of air to feed the up-currents which arise from the hot equatorial belt, which for this reason is known to earthly meteorologists as the inter-tropical convergence zone. This zone only corresponds to the equator at about the equinoxes; at other

times it shifts somewhat into whichever hemisphere is undergoing Summer. The winds, however, do not blow directly from north and south towards the hot belt, because the rotation of the Earth causes them to be deflected towards the right in the northern hemisphere, and towards the left in the southern hemisphere.

The reason for this deflection can be seen if one draws an arrow on any part of a globe to represent the wind direction, and then turns the globe round in the direction in which the earth rotates. It will then be seen that the arrow continually changes its direction and, if in the northern hemisphere, points more and more to the left as it is carried round. The wind, however, possesses inertia and tries to carry on in the same direction as before, with the result that it blows to the right of the arrow. Anyone sitting on the surface, unaware that the arrow was turning round in space, would naturally conclude that the wind had veered to the right.

Hence any wind blowing to the equator from the north becomes a north-east wind (the "north-east trades") and similarly winds coming from the south become the "south-east trades." Winds blowing from the Winter hemisphere will have to cross the equator to reach the hot belt, so will deviate first one way, then the other.

One might expect the hot belt to encircle the Earth at the latitude where the sun passes directly overhead at noon; and so it does, more or less, over the continents. But the sea always lags behind the land in its temperature changes, and over the Atlantic and Pacific oceans the convergence zone only shifts a few degrees from the equator at the solstices. Only in the Indian ocean does the zone shift so far that the trade wind crosses the equator to reach it and undergoes a second deviation which is then called a "monsoon."

Coming to Mars, McLaughlin puts his warm convergence zone mostly at about latitude 30° S. during the southern Summer, which is when Mars is nearest the Sun and consequently, according to him, the winds should be at their strongest. An independent estimate was made in 1950 by Seymour L. Hess, an American meteorologist who was giving the Martian atmosphere some attention at that time.[5] He combined a lot of temperature observations by astronomers into a map which put the warm zone during the southern Summer at latitude 20° S., except for an "anomalous" warm patch at 30° S. in longitude 350°. But he proposed a pressure distribution, which he admitted to be rather imaginative, resulting in divergent winds, instead of convergent, occupying at least half the warm belt. I think we can ignore his winds in favour of McLaughlin, who curiously enough does not refer to Hess at all.

At Summer solstice in the southern hemisphere of Mars the noonday sun is overhead in latitude 25° S. Since the Martian surface is all land and no sea, we should expect the warm convergence zone to follow the sun closely and to be at about this latitude. But in considering the trade winds there is another important difference between Mars and the Earth. The only steady trade winds are found over the oceans; over continents they become erratic. This could be attributed partly to the contrast of heating between land and sea—an effect which would not apply on Mars—and partly to localized differences of heating over land, due to contrasts between types of vegetation,

between the moisture content of soils, and between the slopes of the surface in hilly country—all of which contrast effects would be diminished on Mars.

There is one point which McLaughlin does not mention: the fact that the "inter-tropical convergence zone" on the Earth is occupied, at least over the land, by a line of huge thunderstorms which are set going by the up-currents. Clouds are normally produced when rising air cools down to its dew-point, which is does because it expands while rising, owing to the diminishing pressure on top of it. One would therefore expect clouds on Mars to favour the warm convergence zone, but no one appears to have noticed such a phenomenon.

On the whole, however, McLaughlin's trade-wind system seems plausible.

His other main wind system is a supposed series of anticyclones corresponding with the series of light-coloured "desert" regions which encircle the globe between 35° and 55° S.; the outflowing winds would keep these regions clear of dark volcanic matter. The only objection is that they are stationary—so much so that each desert has been given a name, whereas the similar belt of high-pressure regions on the Earth is much more mobile.

Shapes of the dark areas

The most important of McLaughlin's supposed volcanic sources lie north of the equator in the region of the Syrtis Major, the two prongs of the "Forked Bay," and the Margaritifer Sinus, and all these formations show a double curvature corresponding to the changing direction of the postulated trade winds as they cross the equator in the southern Summer. On the other side of the planet the "sources" are south of the equator, and, according to McLaughlin, give rise to the series of parallel "seas," as they used to be called, which are named Sirenum, Cimmerium and Tyrrhenum; they all run from N.W. to S.E., in regions where the original N.E. trades have become N.W. winds after crossing the equator.

To go through all past records of the changes undergone by every Martian feature, in an attempt to deduce the varying local winds on McLaughlin's theory, would be an immense task, which he or someone else may attempt some day. For the present let us deal with a few recorded changes in the best-known feature, the Syrtis Major. This has a shape which suggests a point source of dark matter in about latitude 20° N., which spreads out as it travels first to the S.W. as far as the equator and then to the S.E., thus forming a wedge-shaped area with a double twist.

In my letter to the *J.B.I.S.* of March-April, 1955,[1] it was explained that, whereas matter from a point source in a uniform non-turbulent wind would streak away in a narrow line (suggesting a cause for the Martian "canals"), in turbulent winds it would spread out in the shape of a parabola with ill-defined edges. This was first shown many years ago by Sir Geoffrey Taylor.

To explain it in very simplified form, imagine four smoke particles emerging from a chimney-top into turbulent air which spreads them apart. Two go left, two go right; then, of the two which went left, one goes further left and the other moves right, regaining the centre-line. Of the two which went right, one also returns to the centre line and the other diverges further from it.

Now, if you imagine millions of smoke particles behaving like this, and are possessed of Sir Geoffrey's mathematical genius, you will find that the region where the particles are dense enough to be visible has the outline of a parabola; any change in the degree of visibility only changes the size of the parabola, and there will always be a concentration of particles towards the centre, corresponding to the mean wind direction, and an increasing sparsity to either side, but with no defined limit to which particles can be spread by turbulent eddies. Furthermore, the greatest concentration of particles along the centre line will be near the point source, diminishing further down wind.

The Syrtis Major, like most of the dark areas, is often drawn with very sharply defined edges, with its northern end shown as a sharp point, and the two sides diverge at an ever-increasing angle, instead of a decreasing divergence as in a parabola. The sharp edge might be explained as an optical illusion, as photographs do not show it, but photographs would not be expected to do so, because of atmospheric unsteadiness during the exposure.

Here is a description of the appearance of the Syrtis Major as seen during 1941[6]: "Fairly regular triangular shape: wide and stumpy at first, but from late September pointed and tapering to most observers, though still blunt to one or two . . . . Seems to have darkened appreciably from late September, being often very dark, comparable with Sinus Sabaeus. Most observers at times saw it uniformly dark, but often darkest at the tip (North), and W. edge, and sometimes E. edge also, with lighter patches in South. N. tip and W. edge very dark too." (Southern Summer solstice was on 10 September). Some parts of this description, at least, seem consistent with the idea of a point source and occasional limited changes in wind direction.

McLaughlin admits that there are certain difficulties in his theory, and has thought up some ingenious ways of getting round them, after disarming us by saying that "there is always a great temptation to overwork a new hypothesis by using it to explain everything in sight." For instance, where a "canal" fails to correspond to the wind direction, he supposes it to consist of a line of small volcanoes along a crack resembling a geological rift or fault. But one difficulty, which he has not tackled, is that when the winds are weak owing to Mars being further from the Sun, or owing to the point source being in the doldrums, there should be a greater concentration of matter round each major source, making it more conspicuous than at other times, and there seems no observational evidence of this.

Composition of the dark material

McLaughlin points out that observation of the polarized light reflected from Mars at various angles of incidence, made by Lyot, Dolfuss and others, show a result characteristic of volcanic ash. He ignores, however, one observation by Lyot which is reported by G. de Vaucouleurs[7]; Lyot found in 1926 that, in a particular area around the Mare Chronium, light from the dark regions was polarized as if the surface was covered with objects "elongated in the vertical direction."

There is one strong objection to the idea that the characteristic shapes of the dark areas are formed when the solar radiation, and the consequent winds, are strongest. The annual darkening of these areas does not start at the tropics but in the polar regions, and there is a strong presumption that it is caused by the slow spread of moisture from a melting polar cap.

In his second article McLaughlin goes rather deeply into the possible chemistry of the dark matter, after having consulted, especially, a "Treatise on Metamorphism" by C. R. Van Hise (U.S. Geological Survey Monograph No. 47, published 1904). He has been able to find reasons for thinking that, when exposed to the Martian atmosphere, common types of volcanic ash would weather to a soil in which green chlorite and epidote would be abundant, and that in powdery form this material would darken on moistening. Professor H. C. Urey has even suggested to him, in a private letter, that "the darkening may be due to moisture that has come out of the volcanoes."

This suggestion, one may remark, provides hope yet for the believers in the vegetation theory. If we suppose that the Martian plants thrive on moisture coming out of McLaughlin's volcanoes, then the shapes of the dark areas, and their annual resuscitation in the winds of the southern Summer, are all accounted for by a combination of his volcanism with his meteorology, but only with the assistance of still more moisture from the polar cap.

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(1) A. E. Slater, "Some Remarks on Strughold's Ideas," *J.B.I.S.*, **14** (2), 119, Mar.-Apr., 1955.
(2) D. B. McLaughlin, "Wind Patterns and Volcanoes on Mars," *The Observatory*, **74**, 167–8, August, 1954.
(3) D. B. McLaughlin, "Interpretation of some Martian Features," *Publications of the Astronomical Society of the Pacific*, **66**, 161–170, August, 1954.
(4) D. B. McLaughlin, "Further Notes on Martian Features," *Publications of the Astronomical Society of the Pacific*, **66**, 221–229, October, 1954.
(5) S. L. Hess, "Some Aspects of the Meteorology of Mars," *Journal of Meteorology*, **7** (1), 1–13, February, 1950.
(6) Twenty-fourth Report of the Section for the Observation of Mars, dealing with the Apparition of 1941, *Memoirs of the British Astronomical Association*, **37** (1), 7, 1951.
(7) G. de Vaucouleurs, *Physics of the Planet Mars*, Faber & Faber, Ltd., London, 260–1, 1954.

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TECHNICAL REVIEW

British High-altitude Rocket Research Programme

The following announcement was made on August 3, 1955 by Sir David Brunt, the Secretary of the Royal Society.

"The wind, temperature, humidity and other properties of the atmosphere up to heights of about 20 miles can be studied directly by means of instruments carried up by free balloons. Observations of this kind are regularly made by meteorological services throughout the world. Although the atmosphere at greater heights is very tenuous, it necessarily plays an important part in many phenomena. Thus long-distance radio propagation is only possible because of the existence of reflecting layers, the ionosphere, at altitudes of 60 miles and above—indeed, a very important region extends upwards from a height of 90 miles. Meteors are mainly evaporated at the 60-mile level, and the aurora, at least in high latitudes, is located at about the same level. The electric currents which give rise to the variations of the Earth's magnetic field circulate in this region, and it is also the seat of a night-time air-glow quite distinct from the aurora or the light of Moon and stars.

"Before the Second World War, information about the upper atmosphere could only be obtained by indirect methods. The remarkable developments of rockets as weapons led to the possibility of carrying instruments into the upper air in vehicles of this kind. This was achieved in the United States in 1946, using captured V2 rockets. Since that time steady progress has been made and many interesting results have been obtained. The greatest height reached so far has been 240 miles.

"A research programme of this kind is expensive, and until recently was exclusively carried out by American scientists and technicians. It is very desirable that work should be carried out in other countries, to obtain data under different conditions and locations and employing different techniques. A programme has already been commenced in France, and an extensive programme is now being initiated in the United Kingdom through the co-operation of the Ministry of Supply, particularly the Royal Aircraft Establishment, and the Gassiot Committee of the Royal Society. The programme aims at having available, within two years, rockets able to carry 100 lb. weight of scientific instruments up to heights of 120 miles or more. The design, development, supply and firing of the rockets will be carried out by the Ministry of Supply. Five university research groups, from University College, London (Prof. H. S. W. Massey), the University of Birmingham (Prof. J. Sayers), the Queen's University of Belfast (Profs. D. R. Bates and K. G. Emeléus), University College, Swansea (Dr. W. J. G. Beynon) and the Imperial College of Science and Technology, London (Prof. P. A. Sheppard), will be initial participants in the scientific programme. The work will be co-ordinated through a special subcommittee of the Gassiot Committee of the Royal Society. The first experiments will include determination of atmospheric temperature and density, the study of the nature of the ionosphere, a search for very fine meteoric dust below 60 miles altitude, and determination of the heights of the regions from which the

night air-glow is strongest. While the development of the rockets is proceeding, work on the scientific instruments required will proceed in parallel, so that both should be available at nearly the same time.

"Although this programme has been arranged independently of the International Geophysical Year, 1957–58, it is hoped that it will be in operation during this period and add substantially to the British contribution to the Year."

(Although we are pleased to welcome this programme it is a great pity that it was not initiated at a far earlier date. The British have never been behind in the development of solid-propellant rocket-motors and suitable vehicles for this type of work either existed, or could easily have been made, ten years ago.—ED.)

Guided Missile Training Range

On July 27 the Minister of Defence announced that a range for training the armed forces in the operation of guided missiles was to be established on South Uist in the Outer Hebrides. Although the range will be used by all three services it is primarily for the Royal Air Force and Army.

DAN Research Rocket

DAN is the name of a new upper-atmosphere two-stage research rocket recently announced by the Geophysics Research Directorate of the U.S.A.F. Cambridge Research Center. It consists of a Deacon as a top step and a Nike booster as the bottom step. The first vehicle reached a height of about 73 miles at Wallops Island. It carried a 7-in. diameter aluminium sphere which was released at maximum altitude. By telemetering accelerator readings the drag of the sphere and hence the atmospheric density could be deduced.

World Land Speed Record

On July 26 a rocket-propelled sled of Radio Plane Co., Van Nuys, California, reached a speed of 1,100 m.p.h. This was achieved on the 10,000 ft. Edwards A.F.B. track and is believed to be the highest land speed ever recorded. Top speed was reached in less than 5 secs.

North American Expansion

The new rocket and atomic research laboratories built by North American Aviation, Inc., near Los Angeles will employ a staff of 3,000 and will be in operation by mid-October, 1955.

First Firing of Aerobee-Hi

The first Aerobee-Hi rocket has reached a height of 124 miles. This development of the Aerobee has been made possible by the use of a higher concentration nitric acid giving 10 per cent. better performance, an extremely thin stainless-steel skin and various minor improvements. It is designed to reach 130 miles with a 200-lb. pay-load and it is hoped to reach over 200 miles with a 120-lb. pay-load. This compares with the 75 miles with a 150-lb. pay-load of the Aerobee. Initial cost of the Aerobee-Hi is $30,000, but it is hoped to reduce this to $22,000. A total of five vehicles is on order.

Princeton Hypersonic Wind Tunnel

Steady speeds of mach 15 are being obtained in the hypersonic wind tunnel at the Gas Dynamics Laboratory of Princeton University and it is hoped to reach Mach 20 in the near future. Existing theories of hypersonic flow conflict with the small amount of practical data so far available and more experimental information is needed. The Princeton hypersonic tunnel uses helium as the working medium and has a vacuum ejector system downstream of the test section, discharging to the atmosphere.

High-altitude Test Chamber

Pressure conditions equal to those at 25 miles altitude and temperatures up to 300° C. can be obtained in a new equipment-testing chamber manufactured by the American Research Corporation.

"Atlas" I.B.M.

The Atlas intercontinental ballistic missile will probably only weigh half of the originally planned 500,000 lb. because of improvements in the H-bomb which it is intended to carry. It will be propelled by two sets of rocket motors, one of which will be dropped when it has cleared the atmosphere. For a range of 5,000 miles the top speed will be about 22,000 ft./sec. and total burning will be 12 minutes. It will coast to a peak altitude of 800 miles before returning to Earth—a total flight time of about half an hour. The Convair Division of General Dynamics Corpn. is to make the structure, propellant tanks and possibly the warhead; North American Aviation Inc. are to make the rocket motors, Arma Division of the American Bosch Corp. the guidance system, and Ramo-Wooldridge will probably get the contract for the nose section—this is all-important for re-entry at the speeds involved.

DATA SHEETS

By Kenneth W. Gatland, F.R.A.S.

NIKE SAM-A-7—United States of America—Douglas Aircraft Co.

(*a*) Rôle: anti-aircraft, surface-to-air.
(*b*) Origin: 1946 (first firing without guidance); 1951 (first firing with guidance).
(*c*) Length: 20 ft.
(*d*) Diameter, body (max.): 1 ft.
(*e*) Diameter over fins: 2 ft. (nose-vanes).
(*f*) Diameter, over wings: 5·2 ft.
(*g*) Weight, launching: 1,000 lb. (approx.).
(*h*) Weight, propellant: not available.
(*j*) Weight, pay-load: not available.
(*k*) Thrust: not available.
(*l*) Velocity (max.): mach. 2 (cruise).

(*m*) Altitude: 50,000 ft.
(*n*) Range: 18 miles.
(*p*) Propellant: nitric acid/petrol.
(*q*) Feed system: gas pressure.
(*r*) Control: gyro-controlled nose-vanes/command guidance with semi-active radar homing.
(*s*) Booster: tandem unit, solid-propellant (15 ft. × 17 in.) approx.), three-finned.

Notes: Developed for U.S. Army by Army Ordnance Corps, Douglas Aircraft Co., Bell Telephone Laboratories and Western Electric Co. Propulsion unit by Aerojet General Corporation.

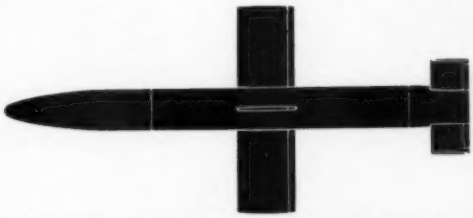
Project commenced in 1945. Prototype produced jointly by Douglas Aircraft Co. and Bell Telephone Laboratories, former developing missile and launching equipment, and latter the guidance system. In production, guidance system manufactured by Western Electric Co.

Also Nike B, larger and with improved guidance system.

REFERENCE

(1) "Development of the Guided Missile," by K. W, Gatland (2nd edition), Iliffe & Sons, London, 1954.

LARK SAM-N-2—United States of America—Fairchild Engine and Airplane Corporation.



(*a*) Rôle: research, surface-to-air (*see* Notes).
(*b*) Origin: 1945 (contract).
(*c*) Length: 14·50 ft.
(*d*) Diameter, body (max.): 1·25 ft.
(*e*) Diameter, over fins: 4 ft.
(*f* Diameter, over wings: 6·25 ft.
(*g*) Weight, launching: 1,210 lb.
(*h*) Weight, propellant: not available.
(*j*) Weight, pay-load: not available.
(*k*) Thrust: not available (two-motor system).
(*l*) Velocity (max.): Mach. 0·9 (cruise).
(*m*) Altitude: not available.
(*n*) Range: 10 miles.
(*p*) Propellant: red fuming nitric acid/aniline.
(*q*) Feed system: gas pressure.
(*r*) Control: aerodynamic surfaces on wings and tail-vanes, gyro controlled/command guidance with semi-active radar homing.
(*s*) Booster: tandem unit comprising two standard Aerojet JATO motors within large box fins (total thrust 2,000 lb.).

NOTES: Employed both as training missile for launching-crews and as experimental vehicle for testing components, in particular, a Fairchild-developed target-homing system. Project originated towards end of World War II as a potential defence against Japanese suicide aircraft.

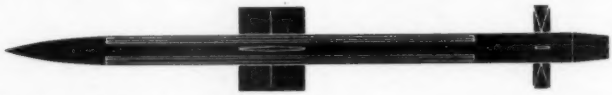
Construction: body consisting of five sections of light alloy, using conventional aircraft monocoque practice, and two tank sections of stainless steel; nosing of Fiberglas. Cruciform wings fabricated as single aluminium extrusions; cruciform tail-vanes moulded from Fiberglas sandwich material. Twin motor propulsion system (Reaction Motors, Inc.).

Developed under contract from the U.S. Navy Bureau of Ordnance by Guided Missile Division of Fairchild Engine & Airplane Corp. in association with other companies. Subsequently used by all three Services, Navy, Army and Air Force, for training and test purposes.

REFERENCE

(1) "Development of the Guided Missile," by K. W. Gatland (2nd edition), Iliffe & Sons, London, 1954.

R.T.V.-1 (Great Britain)—Royal Aircraft Establishment, Farnborough, Rocket Propulsion Dept., Westcott.



(*a*) Rôle: Research, surface-to-air (*see* Notes).
(*b*) Origin: 1947.
(*c*) Length: 17 ft. approx. (varies according to sub-type).
(*d*) Diameter, body (max.): 9·5 in.
(*e*) Diameter, over fins: 2·0 ft. (tail-vanes).
(*f*) Diameter, over wings: 2·25 ft.
(*g*) Weight, launching: 260 lb.
(*h*) Weight, propellant: 130 lb.
(*j*) Weight, pay-load: various, not available.
(*k*) Thrust: 1,075 lb. × 21 sec.
(*l*) Velocity (max.): mach 1·4 (cruise).
(*m*) Altitude: not available.
(*n*) Range: not available.
(*p*) Propellant: liquid oxygen (60 per cent.)/methyl alcohol + water (40 per cent.).
(*q*) Feed system: gas pressure (slow-burning cartridge) applied *via* pistons in tanks.
(*r*) Control: aerodynamic tail vanes, gyro-controlled/command or beam-rider guidance systems.
(*s*) Booster: tandem unit, 6 ft. long × 1·60 ft. diameter, comprising 7 in. × 5 in. standard R.A.T.O. units (total thrust 7,700 lb. × 4 sec)/later boost motors of higher power substituted.

R.T.V. = Research Test Vehicle.

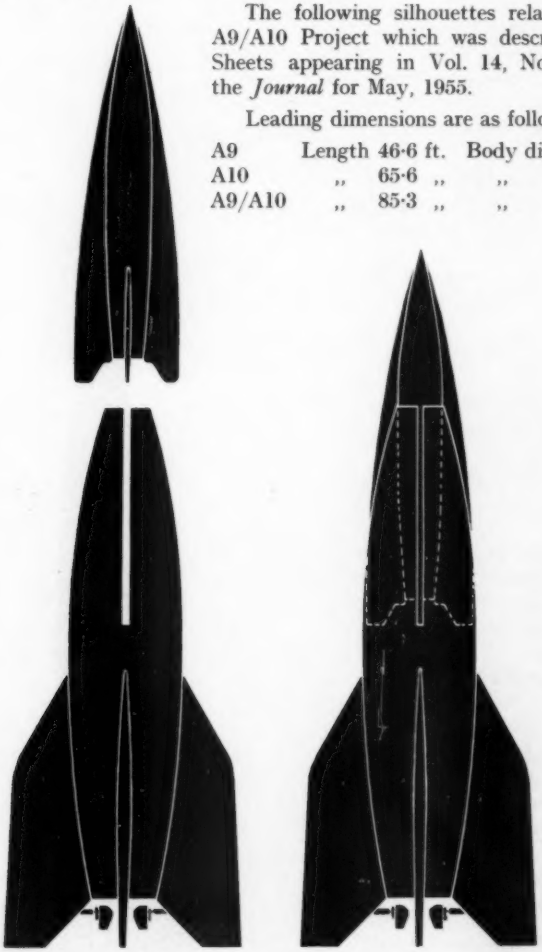
NOTES: Employed for aerodynamic, stability and control test purposes; also for tests of guidance systems. Developed from LOP-GAP (Liquid Oxygen-Petrol, Ground-to-Air Project) in which, however, alcohol was substituted for petrol. Propulsion unit developed by Rocket Propulsion Department, Westcott, Bucks.

Manufactured in England by Marston Excelsior and Armstrong-Whitworth Aircraft, Ltd.; in Australia by Fairey Aviation (Australasia), Ltd.

REFERENCE

(1) "Britain's Guided Missiles," by K. W. Gatland, *R.A.F. Flying Review*, September, 1955.

A9/A10 Project



The following silhouettes relate to the German A9/A10 Project which was described in the Data Sheets appearing in Vol. 14, No. 3 (page 173) of the *Journal* for May, 1955.

Leading dimensions are as follows:—

A9	Length	46·6 ft.		Body diameter		5·4 ft.	
A10	,,	65·6	,,	,,	,,	13·6	,,
A9/A10	,,	85·3	,,	,,	,,	13·6	,,

In America, considerable interest surrounds the Convair Atlas, a two-step intercontinental rocket with the following characteristics: Cut-off velocity (final step) 22,000 ft./sec; peak altitude 800 miles; range 5,000 miles. Principal contractors: Convair (overall project); North American (120,000 lb. thrust rocket engines); General Electric (guidance), and Ramo-Wooldridge (ballistic nose for final step).

A-4/WAC-Corporal No. 5 (Bumper Project)—United States of America—General Electric Company.

(*a*) Rôle: Research, step technique.
(*b*) Origin: 1949 (firing).
(*c*) Length: 62·0 ft. overall (A-4 plus WAC-Corporal).
(*d*) Diameter, body (max.), 5·4 ft. (A-4).
(*e*) Diameter, over fins: 11·75 ft. (A-4), not applicable (WAC-Corporal).
(*f*) Diameter, over wings: not applicable.
(*g*) Weight, launching: 26,895 lb. (A-4 plus WAC-Corporal).
(*h*) Weight, propellant: 19,700 lb. (A-4), not available (WAC-Corporal).
(*j*) Weight, pay-load: 50 lb. instruments (for measuring performance) in final step.
(*k*) Thrust: 60,000 lb. × 60 sec. (A-4), 1,500 lb. × 45 sec. (WAC-Corporal).
(*l*) Velocity (max.): WAC-Corporal, 7,335 ft./sec. (final step).
(*m*) Altitude: 242 miles (final step).
(*n*) Range: not applicable.
(*p*) Propellant: liquid oxygen/alcohol (A-4), nitric acid/aniline (WAC-Corporal).
(*q*) Feed system: turbo-pump (H_2O_2 generator (A-4), gas pressure (WAC-Corporal).
(*r*) Control: gyro-controlled exhaust vanes (A-4); none, dynamically stable (WAC-Corporal).
(*s*) Booster: A-4 (modified).

NOTES: Fifth of eight similar rocket vehicles designed to investigate step technique under U.S. Army Ordnance contract.

Launched at White Sands, New Mexico, February 1949, at angle of 10 degrees to vertical to counteract Earth's rotation and ensure descent

Bumper-WAC (No. 5).

Length: 16 ft.
Hull diameter: 1 ft.

Wac-Corporal

Scale: 1 in. = 5 ft.

of final step within perimeter of proving ground. WAC-Corporal released at altitude of 20 miles, near climax of A-4's thrust period.

Others of series fired from Cape Canaveral, Florida, to obtain maximum horizontal range (results not disclosed).

Modified rocket systems designed by Jet Propulsion Laboratory, California Institute of Technology; modified A-4 nose built by Douglas Aircraft Co. General Electric Co. responsible for overall project.

Has furnished experience for U.S. Minimum Satellite Vehicle, probably with Redstone and Aerobee-Hi as 1st and 2nd steps, with final step of special design.

REFERENCE

(1) "Development of the Guided Missile," by K. W. Gatland (2nd edition), Iliffe & Sons, London, 1954.
(2) "A Report on the Bumper Programme" by R. P. Haviland, *J.B.I.S.*, Jan., 1952, pp. 9–13.

NOTES AND NEWS

Technical Study Groups

The response to the invitation extended by the Council for the formation of Technical Study Groups (*J.B.I.S.* 14, No. 3, May, 1955) has been very poor, for only fourteen members expressed an interest in these Groups, and they were scattered over the country and did not appear to have any common subjects. In addition, no one volunteered to undertake the formation and administration of such Groups, and it seems that the original plea proposed at the last Annual General Meeting cannot be adopted as originally envisaged.

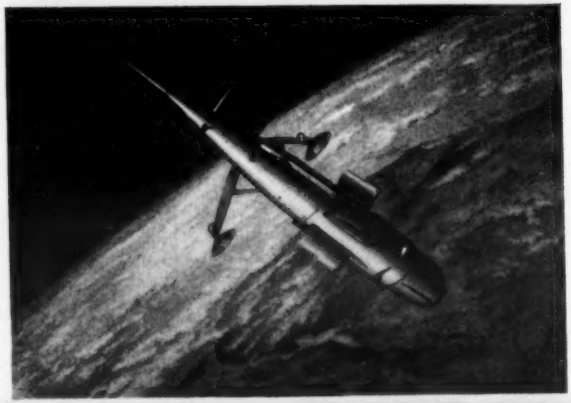
However, a very flourishing Technical Study Group exists in the Midlands Branch under the Chairmanship of Mr. D. A. Parish, 18, Arundel Road, Hollywood, Birmingham, and all members who feel that they might be able to make useful contributions to the work of this Group are invited to write to him.

B.I.S. Gold Medal

A total of 22 designs were submitted by Members for the Council to consider in connection with the Society's Gold Medal to be awarded, as occasion arises, in recognition of original research which significantly advances the attainment of space-flight.

The design chosen was one submitted by Mr. R. Turner, originally prepared as a design for the Society's badge. The designs submitted by Mr. Mellanby and Mr. S. F. Smith also disclosed considerable artistic ability.

B.I.S. CHRISTMAS CARDS



Above: Spaceship landing on the Mare Imbrium, with the great isolated peak of Piton a few miles to the east. The speed of the rocket when landing is being slowed by using a jet as a brake.

Top left: Winged Rocket Returning to Earth with the aid of braking parachutes.

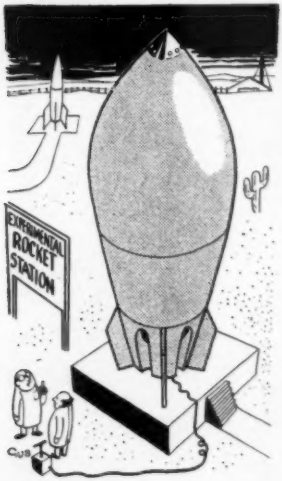
Bottom left: An Orbital Telecontrol Rocket about 200 miles above the Earth's surface, where it completes each revolution in about 1¼ hours.

In making their final selection, the Council were keenly aware of the interest and support shown by all the members participating, and wish to extend to them their grateful thanks for the designs submitted.

Acta Astronautica

Members of the Society are reminded that they can subscribe to the above volume at a special reduced rate of 20 per cent. from the normal price, i.e. for a net amount of £2s 10s. per annum.

Subscriptions may be placed through any bookseller, who should be advised that the subscriber is a member of the B.I.S.



"All right then, as it's Guy Fawkes night—just one."

Reproduced by courtesy of the Editor of "The Evening News"

Outside Lectures in the London Area

A considerable number of requests for lecturers by Youth Clubs and social organizations of all types in the London area cannot be fulfilled owing to a shortage of suitable speakers, and an appeal is therefore made for additional assistance from *Fellows*, who may wish to give an occasional talk to such organizations.

The acceptance of any particular lecture is entirely a matter for the individual concerned, and inclusion in the Society's Lecture Panel does not involve any obligation.

Lecture Notes have been circulated to all Members with the September 1953 *Journal*, and copies of the Society's film strip are also now generally available.

Lectures to the type of organization referred to are usually of a very general nature, and do not normally carry a fee, though expenses are generally refunded.

SOCIETY CHRISTMAS CARDS

A selection of 3 different Christmas cards are available for 1955, these consisting of reproductions of the following drawings from "*Exploration of the Moon*" by R. A. Smith and A. C. Clarke.

(a) Manned Rocket Landing
(b) Winged Rocket Returning to Earth
(c) Instrument Carrying Rocket in Orbit.

Grateful acknowledgements for permission to reproduce these illustrations are given to the artist Mr. R. A. Smith, and the publishers, Frederick Muller Ltd.

We hope that all members will make use of these attractive cards, which can be obtained from the BIS Secretary at a cost of 5/6 per dozen (*minimum quantity*) post free. Please state the quantity of each type of card required when ordering.

Drawn by R. A. Smith.

Illustration for the 1956 B.I.S. Calendar.

B.I.S. Calendars—see illustration opposite

The Council has approved the issue of a Society Calendar for the year 1956, which is available to members at a price of 2s. 9d., post free.

The Calendar shows the picture of a Lunar Rocket Landing (reproduced opposite) which originally appeared in the *Exploration of Space* (by A. C. Clarke and published by Temple Press Ltd.), and which has been made available by courtesy of the artist, Mr. R. A. Smith.

It is hoped that many members will avail themselves of this calendar, and may also wish to purchase copies on behalf of their friends.

Prof. Hermann Oberth

Prof. Hermann Oberth has joined the U.S. Army Ordnance Guided Missile Development Center, Redstone Arsenal, Huntsville, U.S.A.

Flying Saucers—An Uncompromising Statement

"The Air Force has stated in the past, and reaffirms at the present time, that unexplained aerial phenomena are not a secret weapon, missile, or aircraft, developed by the United States. None of the three military departments nor any other agency in the Government is conducting experiments, classified or otherwise, with flying objects which could be a basis for the reported phenomena.

By the same token, no authentic physical evidence has been received establishing the existence of spaceships from other planets."

Annual General Meeting

Members are reminded that the Tenth Annual General Meeting of the Society will be held on April 21, 1956, and the Accounts and Chairman's speech will appear in the March, 1956, *Journal*, instead of the present issue as hitherto.

Technical Papers at Innsbruck Congress

Springer-Verlag have published the technical papers presented at the Innsbruck Congress in a volume which runs to 307 pages. The cost is £4 18s. 6d.

Astronomical Photographs—A Correction

A correction should be made to the information contained in the review on page 288 of the September-October, 1955, B.I.S. *Journal*, which did not make it clear that the catalogue of astronomical photographs obtainable from the Royal Astronomical Society cost 5s. to non-members (3s. to Fellows of the R.A.S.). The R.A.S. catalogue contains 39 pages and is not illustrated.

An illustrated catalogue is obtainable from the University of Chicago Press, Chicago, Illinois, U.S.A., and runs to 32 pages. It is issued free.

Erratum

Mr. Nicoll has pointed out that the statement in his paper, "A Life Compartment suitable for Space Travel" (p. 281, September, 1954 *Journal*) reading "3·3 revolutions per minute" should read, "one revolution in 3·3 seconds."

New Photographic Sky Atlas

The first section of a new Photographic Sky Atlas has just been published by Mt. Palomor Observatory after nearly seven years' work. The project began in 1949 and is expected to be finished in 1956. The first section comprises

200 photographs, each 14 in. square, and the complete map will total 1,758 similar photographs, the whole being about the size of a tennis court.

The photographs were taken with the 48-in. Schmidt telescope, which has mapped about three-quarters of the sky to a depth of 600,000,000 light years (each light year is about 6 million million miles) and reveals objects down to 1-millionth of the brightness of the faintest star which can be seen by the naked eye on a dark moonless night.

Each photograph has been taken twice, first in blue light and again in red light, which helps indicate the temperature, colour, and brilliance of distant stars.

The map has revealed many new celestial bodies, e.g., comets, asteroids, stars, and island galaxies. The island galaxies themselves are of particular interest, for not only is there the problem of the recession of the galaxies, but it appears that some island galaxies are themselves grouped into clusters. Previously, only about three dozen of these were known, but the total has now reached over 1,000 and indicate a new mystery in the nature of the universe.

The problem of the recession of the galaxies may be briefly summarized by mentioning that, the farther these galaxies appear, the greater appears also to be their speed of recession, and some of the most distant galaxies appear to be moving away from us at 38,000 miles per second, i.e., 1/5th of the speed of light itself.

Although the 200-in. telescope can see three times as far as the 48-in. Schmidt telescope, the field of view is much smaller, and it would have taken 10,000 years for the 200-in. to map the entire heavens!

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THE BRITISH ASTRONOMICAL ASSOCIATION

Founded 1890, now numbers 2,000 members. Open to all interested in Astronomy. Chief objects are the association of observers for mutual help, circulation of astronomical information, and encouragement of popular interest in Astronomy. The Association issues a *Journal* about nine times annually, *Circulars* giving current Astronomical news, a *Handbook* annually and *Memoirs* on the work of Sections, including the Sun, Moon, Planets, Comets, Auroræ, and Variable Star Sections.

The Association has a good Lending Library and Lantern Slide Collection. A number of instruments are also available for loan to members.

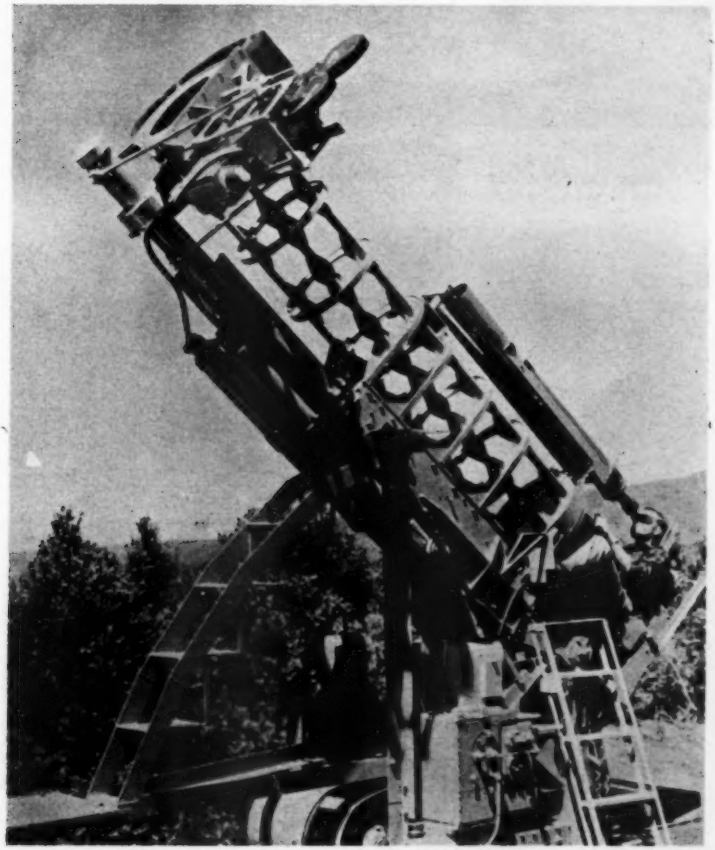
For further particulars apply to—

The Assistant Secretary, 303, Bath Road, Hounslow West, Middlesex.

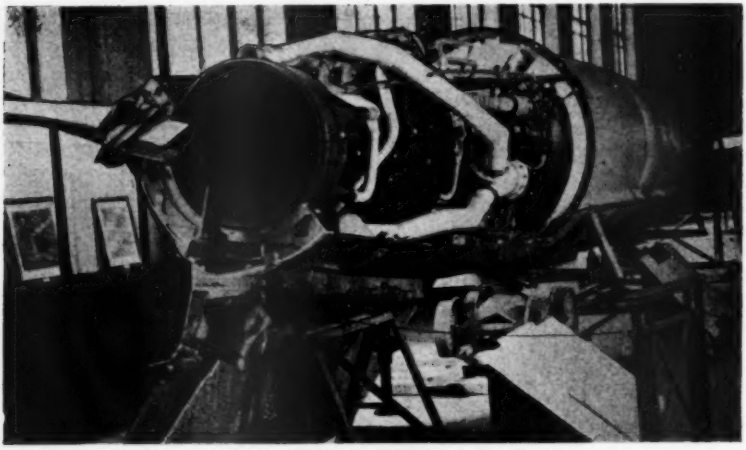
PICTURE SECTION

During the course of each year, the Society receives various photographs, some of which are reproduced in connection with news items, while others are simply filed for future reference. It has been decided that, when enough illustrations of general interest accumulate, they will be reproduced from time to time in a "Pictorial Feature" of the *Journal*. It is also intended to use this opportunity to present pictures of purely historical interest whenever we receive them and an invitation is extended to any members possessing such material to submit it to the Editor on short loan for this purpose.

A list of photographs held by the Society, from whom reproductions can be obtained, is available to all members on request from the B.I.S. Secretary.



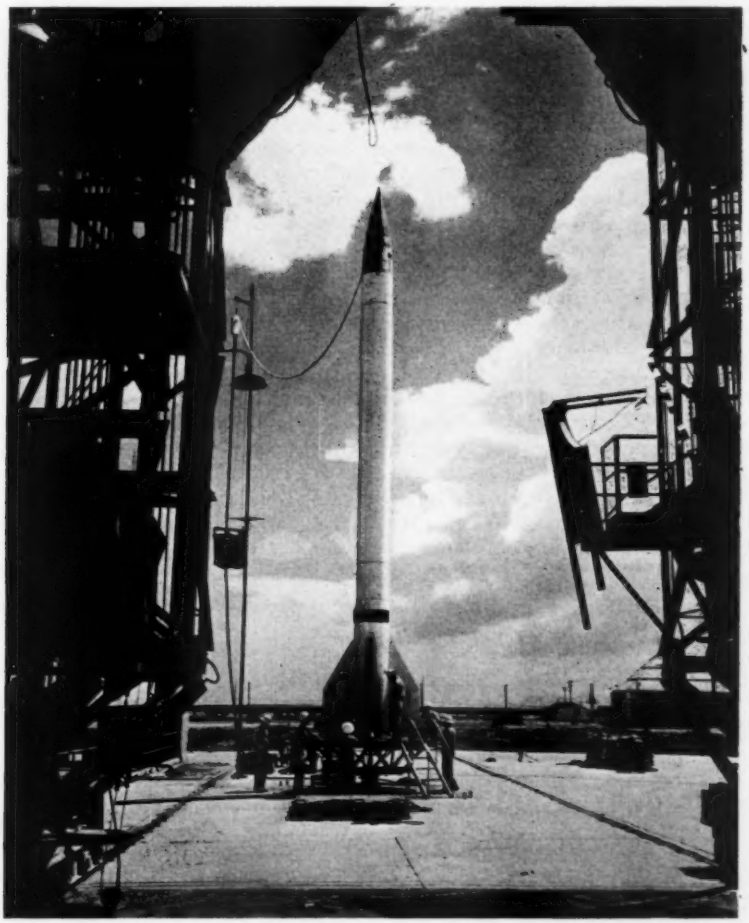
Missile tracking telescope.



V2 ROCKET MOTOR

A view of the V2 on display during the exhibition of German wartime rocket development held in South Kensington Science Museum, London, in 1945.

Lockheed "Starfire" firing "Mighty Mouse" Rockets. (Compare with the picture of the Le Prieur aircraft rockets on page 50 of the January, 1954. *Journal.*)



Viking Rocket No. 7

The U.S. Navy's Viking rocket No. 7 was built by the Glenn L. Martin Co. and is shown here receiving its final test by several technicians prior to launching.

This rocket reached a maximum speed of 4100 m.p.h. and an altitude of 135 miles on August 7, 1951, with a pay-load of 425 lb.

In the foreground is the gantry which provides access to every part of the rocket in the final checks undertaken.

The maximum altitude reached by any rocket in this series is 158 miles, by Viking No. 12, and it is hoped eventually to attain altitudes of 200 miles or so.

SIXTH INTERNATIONAL ASTRONAUTICAL CONGRESS

Copenhagen, August 1-6, 1955

Introduction

The *Dansk Interplanetarisk Selskab* was host-society to the 150 delegates at the Sixth Astronautical Congress which was held at Copenhagen from August 1–6, 1955. The opening of the Congress coincided with an American announcement to launch several artificial satellites in connection with the International Geophysical Year, later followed by a Russian announcement expressing interest in artificial satellite plans also, both of which had the effect of creating world-wide interest in the proceedings.

An informal meeting was held on Sunday evening, July 31, at the Studenterforeningen, at which many old acquaintanceships were renewed and a welcome given to those attending for the first time.

The official business began at 8.0 a.m. on Monday, August 1 with the first Session of Delegates, which was held in the Technical University of Denmark. Mr. E. Buch Andersen, President of the DIS, and F. C. Durant III, President of the IAF, welcomed the Delegates. Mr. Durant drew attention to the American announcement of the artificial satellite project, and proposed that a telegram be sent to President Eisenhower advising him of the support of the IAF in these proposals and its desire to help in bringing them into effect. Further business sessions occupied the whole of the following day, August 2, with an additional Session on the Thursday afternoon.

Membership

The official delegates of each Member-Society introduced themselves and described briefly the activities of their societies. Particulars of the total membership of each Society as at July 1, 1955, are detailed in Appendix A.

A new Society, from Chile, was admitted to the IAF, and observers from Belgium and U.S.S.R. were warmly welcomed, the President expressing the hope that societies from these two countries would seek admittance to the IAF next year. The Belgian delegation was present during the whole of the proceedings, while the Russian delegation, which arrived later, consisted of Academician L. I. Sedov, Chairman of the Interplanetary Commission of the U.S.S.R. Academy of Sciences (a Soviet government-sponsored commission charged with the task of investigating the possibilities of satellite vehicles and space-flight) and Professor K. F. Ogorodnikov, an astronomer from the University of Leningrad.

It was also resolved that the Stuttgart *Deutsche Raketen-und Raumfahrt-museum*, a society of 62 persons interested in the history of astronautics, be elected a non-voting member.

A discussion took place on whether a special IAF Membership should be created to provide for the admittance of Universities and similar interested organisations. This was referred to a special sub-Committee under the Chairmanship of Dr. H. C. Christensen, which later recommended that such a grade of membership be created. Accordingly, various Resolutions to amend the Constitution and give effect to this were approved—the annual dues of such organizations being fixed at $50.00.

Finance

The Finance Committee, met under the Chairmanship of Professor T. Tabanera to consider the IAF budget for 1955–6. The normal running expenses were expected to total about $700, but the proposals finally adopted involved raising a sum of $1,000, the increase over the previous year being due to the fact that it was thought desirable to provide financial assistance of up to $300, if necessary, to societies undertaking future Congresses.

This Congress allowance was felt to be of great importance, as it would defray much of the cost of the hire of rooms and other essential arrangements, and so make it possible for societies with relatively small financial resources to undertake what would otherwise be a most difficult task. The grant is to be administered by the Finance Committee, who will be responsible for dealing with applications for aid direct.

The Committee were unable to recommend on this occasion the provision of funds for building up books and films in the IAF archives, although both things were very desirable.

It was resolved that this total of $1,000 be raised by a subscription of $350 each from the BIS and ARS, $100 from the GfW, and the balance from the remaining societies in the proportions of $10 for those having under 200 members and $20 for those having over 200 members.

These proposals were later submitted to the delegates and approved unanimously.

It was resolved that the Finance Committee be re-elected under the Chairmanship of Professor Tabanera.

Publications

Captain G. Partel circulated proofs of the *Glossary of Astronautical Terms* which would be ready for publication shortly, while Professor F. Hecht stated that 240 subscriptions to *Astronautica Acta* had so far been received. He said that the publishers proposed to increase the number of pages of each issue, and would consider reducing the price as soon as 600 to 700 subscriptions had been received. Meanwhile, he hoped that all Member-Societies would publicize *Astronautica Acta* in their respective Journals in an endeavour to build up sales as soon as possible.

Professor Hecht also reported that Springer-Verlag, Vienna, had published the Proceedings of the Innsbruck Congress under the title of *Bericht über den V Internationalen Astronautischen Kongress* (edited by F. Hecht, 307 pp., available in England at a price of £4 18s. 6d., limp covers).

International Relations

Mr. A. G. Haley reported on his endeavours to secure a greater degree of recognition of the IAF internationally, and the formation of societies in countries where there were, at present, no existing Member-Societies, particularly France and Mexico. This was followed by a general discussion of the possibility of forming new societies in other countries.

Next Congress

The *Associazzioni Italiana Razzi* announced that they would be pleased to undertake the arrangements for the 1956 Congress in Rome, and suggested,

provisionally, the dates September 9–15, though these were subject to confirmation later.

This proposal was unanimously accepted by the delegates.

The delegate for the *Agrupacion Astronautica Espanola* mentioned that his society would be pleased to make arrangements for the 1957 Congress to be held in Spain.

Election of Officials

Mr. F. C. Durant III, who had been President for the two previous years, was again unanimously elected for a further term, a nomination of Dr. Shepherd by the ARS having been withdrawn. Professor Tabanera was re-elected Vice-President and in accordance with the IAF practice, the second Vice-President was chosen by the host-Society for the next Congress; it was announced by the AIR that they nominated Professor-General G. A. Crocco.

Ing. J. A. Stemmer was re-elected Secretary.

Social Evening

A number of social occasions were arranged during the week, these including a sailing trip from Tuborg Haven to Landskrona, Sweden, on Thursday, and a visit to Carlsberg Breweries on Friday.

On August 6 a social evening was held at the Studenterforeningen, while earlier in the week a visit to the Georg Jensen silver smithy was arranged for the ladies only.

EARTH SATELLITE

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EYRE AND SPOTTISWOODE

APPENDIX A

LIST OF I.A.F. MEMBER-SOCIETIES

		Membership at	
		5th Cong. (1954)	*6th Cong.* (1955)
Argentina.	Sociedad Argentina Interplanetaria ..	280	480
Austria.	Oesterreichische Gesellschaft für Weltraumforschung	110	120
Brazil.	Sociedade Interplanetaria Brasileira ..	164	450
Chile.	Sociedad Interplanetaria Chilena	—	50
Denmark.	Dansk Interplanetarisk Selskab	31	30
Egypt.	Egyptian Astronautical Society	27	56
Germany.	Deutsches Raketen und Raumfahrt-Museum		62
,,	Gesellschaft für Weltraumforschung ..	803	800
Holland.	Nederlandse Vereniging voor Ruimtevaart	160	180
Italy.	Associazzioni Italiana Razzi	130	156
Japan.	Japanese Astronautical Society	151	218
Norway.	Norsk Interplanetarisk Selskap	39	55
Spain.	Agrupacion Astronautica Espanola ..	62	96
Sweden.	Svenska Interplanetarisk Selskap	67	74
Switzerland.	Schweizerische Astronautische Arbeitsgemeinschaft	61	57
Union of South Africa.	South African Interplanaetary Society ..	63	62
U.K.	British Interplanetary Society	2,521	2,628
U.S.A.	American Rocket Society	2,799	3,000
,,	American Astronautical Society	64	275
Yugoslavia	Yugoslav Astronautical Society	58	119
		7,590	8,968

Additional Notes:—

(1) It is understood that the three Scandinavian Societies are proposing to merge and form a single body.

(2) A new Society, *Polskie Towarzystwo Astronautyczne*, was formed in Warsaw at the end of 1954 with Professor K. Zarankiewicz as Chairman and O. Wolczek as Secretary.

(3) It is understood that societies are in process of formation in France, Belgium and Peru, and that several small amateur groups with similar interests exist in the U.S.S.R.

ABSTRACTS

Edited by J. HUMPHRIES

A list of abbreviations of titles of journals was included with the 1954 index and an addendum was given in the last *Journal*. A further addendum is given below.

J. Operations Res. Soc.—Journal of the Operations Research Society.
Month. Notes Astr. Soc. S. Afr.—Monthly Notes of the Astronomical Society of South Africa.

AIRCRAFT

(194) **Rocket engines on helicopter rotor tips**. *Autom. Ind.*, **111,** 56 (*Oct.* 1, 1954).

(195) **Prospects and problems of rocket propulsion for aircraft.** A. D. Baxter. *Engr.*, **199,** 246–249 (*Feb.* 18, 1955).

(196) **Rocket power for helicopters.** E. Bergaust. *Aero Dig.*, **70** (4), 32, 35–38 *April*, 1955). The application of rockets to helicopters appears to be most suitable for one-man military craft. Both solid- and liquid-propellant installations are discussed with examples of both. Such installations give up to 100 per cent. increase in pay-load, increase in hovering ceiling, and improvement of glide range by a factor of 3 or 4 with the main power plant inoperative.

(197) **The opportunity that was not seized.** D. A. Anderton. *Aviation Wk.*, **26** (5), 28–30, 32, 34 (*Jan.* 31, 1955). Survey of the RAE-Vickers transonic rocket-propelled pilotless aircraft experiments. Of eight vehicles dropped only one successful flight was obtained and the project then cancelled.

ASTRONAUTICS

(198) **The MOUSE (Minimum Orbital Unmanned Satellite of the Earth).** *Sky & Telescope*, **14,** 15, 17 (1954). Details of satellite carrying 50 kg. pay-load at 320 km. altitude.

(199) **Space travel.** W. P. Hirst. *Month. Notes Astr. Soc. S. Afr.*, **13,** 92–96 (1954). Survey of artificial satellites.

(200) **MOUSE (Minimum Orbital Unmanned Satellite of the Earth).** S. F. Singer. *Ciel & Terre*, **70,** 393–400 (1954) (*in French*). Details of satellite carrying 50 kg. pay-load at 320 km. altitude.

(201) **Rocket group urges satellite study.** D. A. Anderton. *Aviation Wk.*, **62** (13), 28–30, 32, 34 (*March* 28, 1955). Résumé of recommendations forwarded to the National Science Foundation by the Space Flight Committee of the A.R.S. The utility of a small instrumented artificial satellite to astronomy, biology, astrophysics, meteorology, geodesy and communications are pointed out and a detailed study of these and other uses urged.

(202) **Solar energy could drive spaceship's electrostatic power-plant, I.R.E. hears.** P. J. Klass. *Aviation Wk.*, **62** (17), 76, 78, 81–82 (*April* 25, 1955). Dr. Ernst Stuhlinger proposes the use of a cluster of parabolic mirrors for converting solar to electrical energy, *via* a conventional boiler-turbo-alternator system or thermo-couples, and using this in an "ion-drive" rocket. The ions would be produced from rubidium or caesium. A space-ship carrying ten passengers plus a 50-ton pay-load from an Earth-orbit to a Moon-orbit would weigh only 250 tons compared with 1,100 tons for a conventional chemically-propelled ship.

(203) **Spaceship instrument study needed now.** G. W. Hoover. *Aviation Wk.*, **62** (18), 30, 32, 34 (*May* 2, 1955). Review of spaceship instrumentation requirements. Considers time, velocity, position, propellant usage and others. Little is known of the problems involved and an immediate investigation is recommended.

(204) **Space-flight is possible (but who'll pay for it?)** S. Bangs. *Interavia*, **10,** 497–501 (*July*, 1955). Description of the Disney film, "Man in Space," and how it was made.

(205) **Engineering problems of manned space-flight.** K. A. Ehricke. *Interavia*, **10,** 506–511 (*July*, 1955). The various problems involved in the development of the manned orbital vehicle, permanent space-station and ships for circumlunar, lunar and interplanetary flight are discussed. Propulsion systems and descent to Earth are dealt with in detail.

(206) **The "Mouse" project.** S. F. Singer. *Interavia*, **10,** 502–504 (*July*, 1955). Uses of instrument-carrying satellite and suggested layout for "Mouse."

(207) **Astronautics in Copenhagen.** E. Burgess. *Flight*, **68,** 270–271. (*Aug.* 19, 1955). Review of papers delivered at Sixth International Astronautical Congress.

ASTRONOMY

See also abs. no. 215.

(208) **The nature and evolution of interstellar matter.** E. Schatzmann. *Astronomie*, **68,** 445–468 (*Dec.*, 1954) (*in French*).

(209) **Martian phenomena suggesting volcanic activity.** T. Saheki. *Sky & Telescope*, **14,** 144–146 (*Feb.*, 1955). Discussion and interpretation of Japanese observations.

(210) **Three riddles of Plato.** J. T. Carle. *Sky & Telescope*, **14,** 221–224 (April, 1955). Discussion of some curious variations observed inside this lunar crater.

(211) **Observations of Mars made at Mount Wilson in 1954.** E. Pettit and R. S. Richardson. *Publ. Astr. Soc. Pacif.*, **67,** 62–77 (*April*, 1955). Account of work undertaken with 60-in. and 100-in. reflectors.

(212) **The ash theory of Martian features.** R. Barker. *J. Brit. Astr. Ass.*, **65,** 235–236 (*June*, 1955). Reasons for untenability of McLaughlin theory that dark areas are due to volcanic ash.

(213) **New findings about Mars.** W. Sinton. *Sky & Telescope*, **14,** 360–364 (*July*, 1955). Account of some recent researches.

ATMOSPHERE

(214) **Exploration of the Earth's upper atmosphere using high-altitude rockets.** D. Brunt. *Nature*, **176,** 282–283 (*Aug.* 13, 1955). The British programme outlined. This aims at having available, within two years, rockets able to carry 100 lb. of instruments to heights of 120 miles.

BIOLOGY AND MEDICINE

(215) **Is life possible on other planets?** G. A. Tikhov. *J. Brit. Astr. Ass.*, **65,** 193–204 (*April*, 1955). Survey of the results obtained by Russian workers in the field of "astrobotany," with special reference to Martian vegetation and possible conditions on Venus.

CHEMISTRY

(216) **Ignition limits of hydrogen-peroxide vapor.** C. N. Satterfield, P. J. Ceccotti and A. H. R. Feldbrugge. *Industr. Engng. Chem.*, **47,** 1040–1043 (*May*, 1955). Data on ignition limits when mixed with inert diluent gases and water vapour. (5 *refs.*).

PHYSICS

(217) **Silicon solar energy converters.** M. B. Prince. *J. Appl. Phys.*, **26,** 534–540 (*May*, 1955). Design theory is discussed and values given for various parameters. Experimental data is presented—up to 6 per cent. efficiency is obtained. The important factor in obtaining such high efficiencies is the reduction of series resistance to as low a value as possible. (4 *refs.*).

(218) **Viscosity and density of the nitric acid-nitrogen dioxide-water system.** D. M. Mason, I. Pether and S. P. Vango. *J. Phys. Chem.*, **59,** 511–516 (*June*, 1955). Measurements made at 0, 25 and 40° C. in the range HNO_3 75–100 per cent., NO_2 0–20 per cent., H_2O 0–5 per cent. (25 *refs.*).

PROJECTILES

(219) **The experimental determination of guided missile reliability.** M. R. Seldon and D. W. Pertschuk. *J. Operations Res. Soc.*, **2,** 31–40 (*Feb.*, 1954).

(220) **Guided missile progam reaches "pay-off."** C. Witze. *Aviation Wk.*, **63** (5), 13–14 (*Jan.* 31, 1955). Reviews present position and discusses problems of Intercontinental Ballistic Missile.

(221) **Engineers probe barriers to I.B.M. flight.** D. A. Anderton. *Aviation Wk.*, **62** (9), 26, 28, 31–32 (*Feb.* 28, 1955). The Intercontinental Ballistic Missile may stand 75 or 100 ft. high and need over 500,000 lb. thrust. Two already developed rocket motors deliver 100,000 lb. each and it may be possible to use a group of these. The major difficulties

are aerodynamic because of lack of data. Of great importance is hypersonic pressure distribution for use in stressing. Aerodynamic heating on the downward path is also largely unknown—one way of dealing with this is to allow the outer skin to melt, but this may upset accuracy on the final approach.

(222) **Missiles move into operational line-up.** D. A. Anderton. *Aviation Wk.*, **62** (11), 104–106, 109 (*March* 14, 1955). Review of existing U.S. missiles and missile problems.

(223) **Operational missiles now arming U.S.A.F.** R. Hotz. *Aviation Wk.*, **62** (12), 14–17 (*March* 21, 1955). Details of Atlas, Falcon, Snark, Navaho, Rascal and Bomarc.

(224) **How a weapon system operates in field.** D. A. Anderton. *Aviation Wk.*, 62 (16), 30–32, 34 (*April* 18, 1955). Description of Nike network, layout of individual sites and methods of on-site handling.

(225) **New rocket boosts space research.** *Aviation Wk.*, **62** (19), 15–16 (*May* 9, 1955). Details of Aerobee-Hi high-altitude research rocket.

(226) **Guided missile maintenance.** C. C. Martin. *Ordnance*, **39**, 891–893 (*May-June*, 1955). Methods of checking and testing required to keep guided missiles serviceable.

(227) **Firing Nike guided missile from anti-aircraft launching sites.** *Aviation Wk.*, **62** (23), 17 (*June* 6, 1955). Photos of erection and firing.

(228) **On top of the World.** *Interavia*, **10**, 504–505 (*July*, 1955). The Viking No: 11, flight and photo. taken from 140 miles altitude.

(229) **Sweden's guided-missile programme.** *Interavia*, **10**, 514–515 (*July*, 1955). Main project is an anti-aircraft missile with a range of 120–150 miles.

(230) **Rocket research and production in Italy.** A. Urbani. *Interavia*, **10**, 513–514 (*July*, 1955). Available facilities and active agencies.

(231) **The world's guided missiles.** A. R. Weyl. *Aeronautics*, **32**, 28–38 (*July*, 1955). Review of the various types and their problems with special reference to the apparent slowness of progress during the past ten years.

(232) **Supersonic models provide missile design short-cuts.** W. J. Coughlin. *Aviation Wk.*, **63** (1), 28–30, 33 (*July* 4, 1955). The use of rocket boosters for free-flight supersonic testing of models. Aerodynamic data is obtained by telemetry and ground tracking.

ROCKET MOTORS

See also abs. nos. 194, 195, 196 and 202.

(233) **Measuring and recording rocket engine performance.** *Autom. Ind.*, **111**, 74 (*Oct.* 1, 1954).

(234) **Servo-stabilization of low-frequency oscillations in liquid propellant rocket motors.** F. E. Marble. *Z. angew. Math. Phys.*, **6**, 1–35 (*Jan.* 25, 1955) (*in German*). Both mono- and bi-propellant systems are considered. Using the Satche diagram the response of a simple feed-back servo-loop can be prescribed to ensure stability for all values of ignition time lag.

(235) **Low-frequency instability in a rocket motor.** M. Barrère and A. Moutet. *Rech. Aéronaut.* (44), 29–38 (*March-April*, 1955) (*in French*). Description of phenomenon and discussion of experimental results. (11 *refs.*).

(236) **Improvements relating to rocket motors and like structures.** The Carborundum Co. *Brit. Pat. No.* 730260, 9 pp. (*May* 18, 1955). Porous ceramic nozzle section for sweat cooling. Suggested ceramic compositions given.

(237) **Improvements in or relating to rocket-type jet propulsion units.** D. Napier & Son, Ltd. *Brit. Pat. No.* 730564, 12 pp. (*May* 25, 1955). A constant chamber pressure unit for varying altitudes.

(238) **Burners for use with rocket motors.** Armstrong-Whitworth Aircraft, Ltd. *Brit. Pat. No.* 731739, 8 pp. (*June* 15, 1955). Impinging-jet type burner of simple fabricated construction.

ROCKET PROPELLANTS

(239) **Reaction motor operable by liquid propellants and method of operating it.** F. J. Malina and J. W. Parsons. *U.S. Pat. No.* 2693077 (1954). Use of hydrazine and carbon disulphide containing phosphorus with white or red fuming nitric acid.

(240) **Handling of oxidants.** *Engng.*, **179,** 184 (*Feb.* 11, 1955). High-pressure flexible hose for use with high-strength hydrogen peroxide.

(241) **Vibrational relaxation times of diatomic molecules and rocket performance.** H. C. Penny and H. Arroeste. *J. Chem. Phys.*, **23,** 1281–1283 (*July*, 1955). Computations for the variation of vibrational excitation probabilities with temperature for mixtures of 0_2 and N_2 and of HF and H_2. The values of six different excitation probabilities in each mixture are reported for temperatures up to 3,000° K. Some considerations are presented which suggest that the expansion through the nozzle for representative H_2/F_2 rocket motors may be taken as vibrational near-equilibrium flow. (**4** *refs.*).

(242) **Processing composite rocket propellants.** A. J. Zaehringer. *Chem. Engng. Progr.*, **51,** 302 (*July*, 1955). Brief review of process methods.

REVIEWS

A Brief Text in Astronomy

(By W. T. Skilling and R. S. Richardson. Published by Henry Holt & Co. in America, by Chapman & Hall, Ltd., in Great Britain. 327 pp., 32/- illus.)

It is stated by the authors that this book has been written for the majority of college students who have time for no more than a one-semester course in astronomy and who may have little or no scientific background. The authors have succeeded admirably in their task—a by-no-means easy one. While many of the ideas and arguments of astronomy are simple and straightforward, the subject is highly technical. A danger overlooked by many an author is that in omitting an explanation of how a result of far-reaching importance has been obtained, because the non-technical reader might not understand, sets up the scientist as a magician producing results like rabbits from a hat. Skilling and Richardson have not fallen into this pitfall. With the aid of clear diagrams, a good, readable style and everyday analogies that only rarely become far-fetched, they enable the student fresh to the subject to gain a vivid impression of the foundations of astronomy, its range and methods, its intellectual value and its present-day progress.

In general, the book follows the well-trodden paths of previous text-books. The first half of the book contains chapters on the Earth, the members of the Solar System, astronomical reference systems, the motions of the planets and the law of gravitation, the Moon, eclipses of Sun and Moon, tides, the Sun, the terrestrial planets and the larger planets. In the second half, the stars are described, their sizes, motions, distances, with a chapter on their internal constitution. Finally, there are two chapters on galactic nebulæ and the galaxies.

A certain amount of new material arising from advances made in recent years has been included. There are sections on radio-astronomy, the discovery of the two stellar populations, and on the recent change made in the distance scale due to the recognition of two types of Cepheid variables. This change doubled the size of the universe outside the Milky Way, made the Great Nebula in Andromeda larger than our own galaxy, and caused many people to ask how the astronomers could have been so much in error. Skilling and Richardson give the reasons.

At the end of each chapter is a set of non-mathematical questions of varying degree in difficulty. At least one is extremely topical. "Suppose that an

artificial satellite was started revolving around the Earth. What would be its approximate minimum distance above the surface of the Earth if it is to remain in a stable orbit?"

One interesting section is devoted to a novel method of finding whether stars have planets. If a star the size of the Sun had a planet the size of Jupiter coming between itself and the Earth, the star's light would be reduced by 1/100 of its usual amount. Such a difference could now be measured with a modern photoelectric photometer. This method has not as yet been used for it remains to find a favourable example of such a stellar planet.

At the end of the book is a glossary of astronomical terms and a useful set of star-maps, one for each month of the year. The illustrations, both photographs and drawings are of high quality, many of the photographs being taken by the 200-in. telescope.

The book can be recommended, not only to those students who have no mathematics, but to all who wish to know more about the methods of astronomical research than is usually revealed in popular accounts.

Only one misspelling was found by the reviewer, Barnard having become Bernard. A. E. Roy.

Man and the Planets

(By R. S. Richardson. Published by Frederick Muller, Ltd. 188 pp., illustrations. 15s. net.).

Written in an enjoyable and friendly style, this book approaches the subject of planetary astronomy with true scientific humility. Dogmatic assertions are conspicuously absent and there are, on the other hand, many indications that Dr. Richardson has himself, that flexible state of mind which he stresses as being essential for the realization of space flight.

The author points out that planetary observing is one of only a few fields in astronomy which are now left for visual work. But the reader quickly gains the impression that Mars is the most interesting of the planets and, indeed, the one other than the Earth on which life, of a kind, is possible.

There are a few points for comment, e.g., an improvement would be made by the omission of the threadbare story of the distortion of "canali" to canals, and there are discrepancies between the text and the figures on p. 25 and p. 39, while the Spartan treatment of velocities for a voyage to Mars could easily have been avoided.

But so many other interesting and lively accounts of astronomy's "present state of ignorance" maintain interest throughout this short book. For those who prefer to believe in Martian life, the author reminds us of the animation teeming just below the inhospitable surface of the bleak Tibetan plateau and of the theory of Öpik that the Martian green areas must be growing things or else they would be obliterated by the frequent dust clouds.

A star map showing the position of Mars every twenty days during the close opposition of 1956 will be useful to those readers who may not be astronomers but should, by its aid, be able to follow the red planet in the star sphere when this approach within 35,200,000 miles takes place.

The book is illustrated by some excellent Palomar photographs and by stills from a new interplanetary film produced by Paramount Pictures.

ERIC BURGESS.

The Viking Rocket Story

(By Milton W. Rosen, Harper & Brothers, New York, 242 pp. $2.75. 1955)

Mr. Rosen has been associated with the Viking high-altitude sounding rocket project since its inception at the U.S. Naval Research Laboratory, and since 1947 has been the Scientific Officer in charge of development of the rocket. The fact that he has had a most intimate knowledge of the multitudinous details and ever-recurring snags and setbacks has enabled him to write a book which should be read by everyone with an interest in rockets. For the amateur, it shows that the usual "simple introduction" to propulsion systems in books on space-flight is no more than an inkling of the amount of sweat and labour that goes into the making of a really reliable high performance rocket power plant: for the professional it gives him some consolation in his darker hours to find that other people have had just as bad a time as he is having, and have managed to get over it. Mr. Rosen has concentrated on the trials of the flight test team at White Sands Proving Ground, and, although there are some wanderings from the main narrative, he has traced the development of the rocket from making only 32 miles altitude (Viking No. 2, September, 1949) to the extremely satisfactory 158 miles achieved with Viking No. 11 on May 24, 1954, and has made plain the difficulties which beset the engineer who has to cope with liquids which are corrosive or extremely cold.

The only faults the reviewer can find in the presentation are an excessive use of journalese and a tendency to mix technical matters with personalities in the same paragraph, and sometimes in the same sentence, but these defects are worth overlooking for the background of information presented. The photographs are excellent.

E. T. B. SMITH

CORRESPONDENCE

Atmospheric Regeneration

DEAR SIR,

Mr. Ross's letter (*J.B.I.S.*, May–June, 1955, p. 180) finally stimulates me to add a contribution to the series arising from Strughold's *The Green and Red Planet.*

Firstly I would like to remark on his masterpiece of understatement that water "may enter into the photosynthesis—respiration equations when disbursement of oxygen is under consideration." The fact is that it most certainly does as the elementary photosynthetic equation

$$CO_2 + H_2O \rightarrow [CH_2O] + O_2$$

tells us.

This is the basic equation of photosynthesis and shows that the hydrogen from the water is used in the reduction of carbon dioxide to carbohydrate, with release of some molecular oxygen. Whether the oxygen arises from the carbon dioxide or from the water is, as far as oxygen production for unit carbon dioxide reduction goes, a purely academic point. In the absence of either one of the reactants the reaction stops despite the presence of the other. Mr. Ross can find his "authoritative confirmation" that most or all of the evolved oxygen in photosynthesis comes from water in reference I.

The above equation also provides an answer to Mr. Ross's query on whether green plants add oxygen to the atmosphere over an extended period. The fact is that they provide precisely the necessary amount to allow the reoxidation of the reduced compounds they produce, completely to carbon dioxide and water, and this includes those reduced compounds ingested by animals and those rotted by bacteria and fungi, etc.

I am not qualified to comment on the effect of thunderstorms in producing oxygen but even Mr. Ross must admit that green plants are capable of maintaining the oxygen balance in the absence of any other oxygen producing mechanism, by the very nature of the reactions involved. Once having accepted the equation above it is merely a matter of simple arithmetic.

Leaving Mr. Ross's letter for the moment I would like to comment on another aspect of the correspondence namely the general emphasis on the necessity of free oxygen to support life. I admit that the more advanced forms do require free oxygen to exist but many of the forms that we know on this planet do not. These forms which include some bacteria, yeasts, etc., can live by anaerobic fermentation. An example lies in brewer's yeast which gains its energy from the reaction:—

$$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$$

Further oxidation of the ethyl alchol produced, however, does require free oxygen (many members will be familiar with this fact) finally to oxidize the fixed carbon to CO_2. This makes it available to green plants so that they can once again synthesize the starting material for yeast fermentation. In general any system of biochemical reactions in living organisms must be cyclical to persist. There is, however, nothing to suggest that a completely cyclical series of reactions in a single organism, which will allow it to exist without exchange with the environment, is impossible. Not only this but there is nothing (as far as I know) to prevent none of the reactants being gaseous and thus possibly lost to the organism. For example, an organism on Mars may live by the following type of reaction:—

$A + B \rightarrow C + D.$ Energy fixing under the influence of sunlight.

$C + D \rightarrow A + B.$ Energy yielding.

If none of these substances were gaseous then the whole cycle could theoretically be carried out within the confines of one organism. This is the sort of idea which seems to have been at the back of Strughold's mind when he suggested the possibility of Martian plants storing oxygen. He could have gone the whole hog and suggested that they also store CO_2 when his suggestion would

have been more similar to the scheme above. However without doing any calculations it seems to me that a normal carbon based organism on Mars would have to have a very efficient storehouse to be able to retain sufficient oxygen for its metabolic needs especially when one considers the low atmosperic pressure on Mars. The question is, however, a complex one, being tied up with rate of metabolism, etc., and I do not propose to pursue it further here. The above scheme is not put forward as what does happen on Mars, it is merely put forward as a theoretical scheme and possible alternative to the "we must have free oxygen for life to exist" school.

Many of the more "practically" minded members of the society may subscribe to the view that anyway we should not waste our time speculating but wait until we get there and find out. This view has, I admit, certain virtues but biologists must use their time in some fashion during the long wait while the engineers are getting down to thinking about building the first spaceship. The depressing thought occurs to me that by the time the first ship is ready I shall myself be free CO_2, H_2O and O_2.

S. S. KIND.

Harrogate, Yorks.

REFERENCE

(1) Hill R. & Whittington C. P., *Photosynthesis*. Methuen, 1955.

(Mr. Ross replies as follows:—

My masterpiece of understatement should be read in conjunction with the paragraph which follows it. A number of people talk about green plants as though they are capable of generating oxygen, whereas unless 100 *per cent. commensalism between man and plant can be realized, oxygen has to be supplied. This will be difficult and probably not worth while except on very protracted voyages, when the vegetation (probably algae) can be used as food. I understand that plant/animal commensalism experiments are now being carried out; however it may well prove easier and more economical to use inorganic processes and reactions rather than photosynthesis.*

I do not quite agree with Mr. Kind that the source of the oxygen liberated by the plant is of purely academic interest; for one thing, the weight of water needed is of practical importance. Nor is the fact that the liberated oxygen comes from the growth-medium and not from the assimilated CO_2 *quite so apparent as Mr. Kind asserts—else, why was the following experiment necessary? Let me quote from Chambers's Encyclopaedia,* 1950 *Edition, p.* 314, *where I recently found the authoritative confirmation which I sought:—*

". . . *photosynthesis is essentially an oxidation-reduction process in which water is oxidized by losing its hydrogen and carbon dioxide is reduced by gaining hydrogen and losing half its oxygen. The process is summarized by* $xCO_2 + yH_2O \rightarrow x(CH_2O) + O_2 + (y-x)H_2O$. *The expression would be simpler if* $x = y$, *but that would imply that one half of the oxygen came from the carbon dioxide and the other from water. Use of the heavy isotope of oxygen,* O^{18}, *has made it possible to show that, in fact, the whole of the oxygen produced comes from water, i.e.,* $y > 2x$, *and hence that half the oxygen from the* CO_2 *must go into a*

substance such as water. This is one of many examples where the ability to label an atom has enabled physiologists to settle old problems. When the O^{18} is introduced into the H_2O some of the O^{18} exchanges with the ordinary oxygen in the CO_2, but the ratio of heavy to normal oxygen in the O_2 produced is always the same as the ratio in the water and independent of that in the CO_2."

I am aware that it is commonly stated that the green vegetation of the Earth is capable of furnishing all the oxygen in the atmosphere in as little as 3,000 *years, but p.* 335, J.B.I.S., 1954 *(for instance) throws some doubt on the efficacy of the process. Indeed, speaking for myself, I am inclined to wonder how the ancient Egyptians managed to build their Pyramids before there was a breathable atmosphere.*

In short, it seems that the terrestrial atmosphere, its source and refreshment, remains something of a mystery despite a century or so of high-pressure biophysics . . . . This, I believe, is also a masterpiece of understatement.)

Strughold's Theories of Martian Vegetation

SIR,

The fact that the oxygen given out by plants is derived from the water they take in, not the carbon dioxide, appears to have been first proved by S. Ruben and co-workers[1] in the year 1941. They proved it by introducing the heavy isotope of oxygen into the water and carbon dioxide, and finding that the proportion of isotope in the liberated oxygen corresponded to that in the water. The plant they used was the green alga *Chlorella*. Other workers have since been reported to have confirmed this finding.

With regard to the other point raised by Mr. H. E. Ross in his letter in *J.B.I.S.* for May-June, 1955,[2] there seem to be two main reasons for supposing that all or most of the oxygen in our atmosphere was put there by plants. One is that it is difficult to account for it all in any other way, and the other is that oxygen produced by vegetation buried in the past, and by that still living which has not yet decayed by oxidation, would together account for an amount of oxygen of the same order as that now present. But the whole question has been put into a state of flux by new lines of reasoning which are well set out by G. P. Kuiper.[3] Incidentally, there is 0·41 per cent. less oxygen in the air over the Antarctic continent than over the rest of the world, according to E. W. Hewson and R. W. Longley.[4] Why?

A. E. SLATER.

Dunstable, Beds.

REFERENCES

(1) S. Ruben, M. Randall, M. Kamen and J. L. Hyde, *Journal of the American Chemical Society*, **63**, 877, 1941; quoted by E. I. Rabinowitch, *Photosynthesis and Related Processes*, Interscience Publishers, Inc., New York, **1**, 54–55, 1945.

(2) H. E. Ross, "Strughold's Theories of Martian Vegetation," *J.B.I.S.*, **14** (3), 180, May-June, 1955.

(3) G. P. Kuiper, *The Atmospheres of the Earth and Planets*, Revised Edition, University of Chicago Press, Chicago, 310–13 and 419–20, 1952.

(4) E. W. Hewson and R. W. Longley, *Meteorology Theoretical and Applied*, John Wiley & Sons, Inc., New York, 11, 1944.